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ABSTRACT

This discussion of the potential of current and projected advances in microcomputer technology for the field of school psychology begins by describing some current applications, including test administration, scoring and analysis, report writing, and data management. Fourteen suggestions for future computer applications in this field are then presented as a way to stimulate creative thinking by the school psychologist who is a also a computer enthusiast. The report concludes with brief discussions of issues in the areas of professional status, ethics, research, and theory, as they relate to current and future computer use by school psychologists. A technical overview is included to provide novices with an introduction to computer technology. A glossary is also provided, and 10 references are listed. (EW)

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Computers in School Psychology: An Overview

by C. Sue McCullough, Ed.D.

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Having been involved with computers since 1980, she has conducted a number of workshops and authored several articles on using computers in school psychology and with emotionally disturbed students. She edited a special computer issue of the *School Psychology Review*, journal of the National Association of School Psychologists, and authored a chapter called "Therapeutic Interventions with the Computer and Seriously Emotionally Disturbed Students" in a soon to be released book on computers and special education, edited by Alex Thomas.

This monograph is published by the International Council for Computers in Education, the United States and international professional organization for computer-using educators. ICCE is dedicated to improving educational uses of computers and to helping both students and teachers become more computer literate. ICCE publishes *The Computing Teacher*, a journal for teachers and for teachers of teachers. It also publishes a number of booklets of interest to educators. Write for a free catalog at the address given below.

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C. Sue McCullough, Ed.D.

October 1, 1984

Preface

Political, social, economic and technological changes affect education and the school psychology profession. In particular, the rapid growth and implementation of microcomputer technology within the schools has the potential to forge massive change. But will we be left with "a jet engine technology pulling an oxcart profession" (Papert, 1980)?

This monograph discusses the potential of current and projected microcomputer technological advances in the profession of school psychology. First, some general definitions of computer applications are offered and some current computer applications are discussed. Then ideas for innovations made possible, and even demanded, by the capabilities and impact of computers in education are considered. In essence, we will explore "what could be" and attempt to expand and stimulate thinking about the impact of computers on the practice of school psychology. Finally, anticipated problems of computer technology as applied to school psychology will be addressed.

A glossary and computer technical overview are included for your reference. Novices are encouraged to begin with the technical overview, which provides an introduction to computer technology with exercises designed to provide practice in associating technical information with school psychology.

This booklet discusses general applications. For more specific information regarding software development and availability, you are directed to other sources of information. For example, the National Association of School Psychologists (NASP) has established a committee on Computer and Technological Applications in School Psychology, (CTASP). CTASP publishes a quarterly computer-users newsletter. In addition, each of the school psychology journals contains articles addressing the topic.

Introduction

Computer technology is in its infancy. With the advent of a single silicon chip with hundreds of electronic components in the early 1960s and the tremendous expansion of microcomputers beginning in the middle 1970s, computer technology has radically changed the culture that has adapted to it. There is little that we do that is not touched in some way by computers. Education, traditionally slow to adapt to technological changes, has incorporated computers into administrative functions readily. Recent surveys found that over 90 percent of U.S. school districts use computers for management purposes, and that by 1985, 80 percent of U.S. schools will be using microcomputers for instructional purposes (Haney, 1982; Polk and Chambers, 1980). A national survey of school psychologists (McCullough, 1982) also indicated high interest in computer applications in daily practice and training settings.

There is one problem to be aware of in exploring this rapidly changing technology: the tendency for the first usable, but still primitive, product of a new technology to dig itself in. Making choices about how to best use the technology is not always easy because past choices often haunt us. As schools acquire Apples, Commodores, Ataris or TRS 80s, new models appear with better features, and new software is released with better programs. But the equipment purchased this year will still be around for years to come, to be replaced only when it is no longer repairable.

In addition, the curriculum and uses designed for the computer may have their basis in an earlier period of technological and theoretical development. A program to teach and provide drill in long division may be written at a time when the computer (or electronic calculator) makes doing long division with paper and pencil anachronistic. Papert (1980) refers to this as the QWERTY phenomenon. The QWERTY (named for the top row of letter keys) arrangement of the keys on the typewriter has no modern rational explanation, only a historical one. In the early days of typewriters, keys stuck together. So the more frequently used keys were separated. As typewriters improved this problem no longer existed, but QWERTY remained. Studies of other arrangements of keys have shown them to be more efficient; people can type faster, with fewer errors. Justifications for the QWERTY arrangement soon become circular and without rational foundation, illustrating a social process of myth construction that allows for continuing primitive, outdated systems. The cost of change and the widespread use of the QWERTY keyboard are used as arguments for resisting change to a more efficient keyboard; similar arguments have been heard about converting to the metric system or continuing use of the Slosson, Binet or WISC intelligence tests.

As microcomputers are assimilated into schools and the school psychology profession, we need to avoid justifying myths with the computer; not let it preserve practices that have only historical basis to justify their existence.

In this monograph I urge you defy the QWERTY phenomenon. Whet your appetite for what could be. Stretch your imagination and creativity. Go beyond the ideas presented here to imagine a school psychology profession that uses computer to their ultimate potential--as extensions of the human mind.

Tool, Tutor, Tester, Tutee

School psychologists use computers in a variety of ways according to the demands of their professional tasks, which include:

*Routine clerical tasks, such as scoring tests or writing reports;

*Data management tasks, such as managing behavioral interventions or producing administrative reports;

*Conducting and interpreting evaluation procedures;

*Instructional and behavioral consultation;

*Therapeutic interventions;

*Preservice or inservice instruction; and

*Research.

The Computer as a Tool

Current school psychology uses fall predominantly under the tool category; the microcomputer is used to assist in routine tasks such as test scoring and analysis, report writing and data management. Tasks that are routine, tedious, mechanical, repetitive, frequently done, requiring complex calculations or taking hundreds of hours to perform by hand can be accomplished with a computer in far less time than by conventional methods. The computer can be programmed to perform useful functions such as word processing, statistical analysis, record keeping, scoring and/or analyzing test results, etc. One study found that using the computer for report writing reduced writing time by 75 percent and costs by 50 percent (Baker, 1983).

Students may also use computers as tools for tasks such as simple word processing and data management. The ease with which words can be manipulated, rewritten, edited and corrected for spelling errors should lead school psychologists to investigate the impact of computers on developing writing skills as well as the implications for remediating written language deficiencies.

The Computer as Tutor

Graduate students in school psychology practice desired feedback and repeated practice as they master a myriad of test administration competencies. First-year students especially want immediate information on their performance (Morris, 1982). The computer can serve as a tutor by providing the necessary information to these students. First, educational material is programmed into the computer by experts in programming and the subject area. The computer presents the subject material, the student responds, and the computer evaluates the response. Based on the results of the evaluation, the computer determines what to present next. At its best, the computer tutor keeps complete records on

each student. It has at its disposal a wide range of subject detail to present, and extensive, flexible methods to test and lead the student through the material. The computer tutor can swiftly tailor the presentation to accommodate a wide range of differences.

For example, computer simulations of the complex scoring of selected WISC-R and WAIS-R verbal subtests provide students with repeated practice in a non-threatening environment. Students are given sample responses to score from the WISC-R Vocabulary, Comprehension and Similarities subtests. They gain immediate feedback on the correctness of their responses. The instructor gains information on the student's mastery level without long hours of direct observation. The student may repeat the randomly generated exercises as often as desired. When the microcomputer is employed for instructional purposes, as in graduate training programs, it falls under the tutor category. Commercial test-writing programs, such as The Learning System by Microlab or Telefacts by dilithium Press, have been used to produce these practice exercises for the WISC-R and WAIS-R.

The Computer as Tester

School psychologists need to perform continuous or periodic assessment of a child's progress toward reaching academic goals. Computer-adapted testing and computer-managed instruction (CMI) use the computer as a tester. In computer-adapted testing the program must contain a large body of facts, skills, and concepts from an array of subject areas. For any given area, the computer selects and tests a subset of skills, facts and concepts, and the individual's basal and ceiling levels are then determined for each area. The computer can then generate and sometimes monitor individualized educational plans or worksheets.

CMI uses frequent tests of mastery to select what to present next in the instructional program. A concept may be repeated, divided into smaller or easier tasks, or expanded upon, depending on the individual's test performance.

Direct observation of an individual's behavior and learning style is another frequent task of school psychologists. It is possible to directly observe a variety of behaviors that occur as an individual interacts with a computer. For example, time on task, reaction time, coordination and problem-solving skills may be directly observed using a computer game format, modified so the computer will record the timed responses. The computer offers the opportunity to not only observe these skills within a standardized setting, but also to teach these skills in a highly motivating environment.

The Computer as Tutee

Not only can the computer provide a mechanism for observing and teaching behaviors, but the individual may also instruct the computer to do specific tasks through programming. The individual becomes the teacher and the computer the tutee.

By necessity, a language must be available that both the computer and the individual "understand." This language is used to both teach and tell the computer to carry out an action, a process called programming. Because the computer is dumb, patient, rigid and has an unlimited capacity for being initialized and starting over from scratch, it makes an excellent tutee. In order to teach the computer, the tutor must: understand the subject area that s/he is trying to teach the computer; learn something about how computers work; and learn how his/her thinking works. The implications of this mode of computer use for school psychology lie in the shift of focus from the end products of

learning to the processes of learning; from acquiring, remembering and repeating facts to manipulating and understanding them.

It is possible to directly observe this problem solving process by watching a child solve problems using programming skills. The programming task creates a unique setting in which the child is teaching the computer rather than the computer teaching the child.

The implications for the evaluation of learning, assessment of learning potential, and the radical changes in the development of thinking skills in children exposed to computer programming or applications from a very early age may provoke major changes in the theories and practices of school psychology.

Young children taught to program the computer with powerful languages such as Logo may come to school with quantitative skills and conceptual, perceptual and reasoning skills not expected at their age. Measurement of these skills with current assessment strategies may not be adequate. Theories of cognitive development may be challenged as the environment to which young children are exposed changes.

It is now time to examine current computer applications in detail.

Current Computer Applications

Currently available school psychology software reflects the needs of the field practitioner. Predominantly, the programs fill needs related to evaluation and record-keeping procedures, including test administration, scoring and analysis, report writing, and data management. In daily practice, heavily influenced by the evaluation demands of PL 94-142, software that provides help with these tasks can increase efficiency, scoring accuracy and standardization of test interpretation; and decrease scoring errors and time, report writing time and interpretive misjudgments. Following are descriptions of current applications. There is an obvious contrast between the description of "what is" which follows the later section on "what could be." This section describes today; tomorrow depends on the informed choices made now.

Test Administration

Few standardized tests used with school-aged children are currently available for computerized administration, in which the child takes the test on the computer rather than with paper and pencil or verbally. However, criterion referenced and teacher-prepared tests directly related to computer assisted instructional programs are readily available. For example, The Psychological Corporation publishes criterion-referenced data banks of math and reading test questions. The tests cannot be taken on the computer, however. The teacher selects test parameters, then prints a hard copy of the test. After the child completes the test, results can be stored on a record-keeping disk for future reference.

Computer managed instructional programs usually contain several tests to judge mastery of the concepts presented. Depending on the child's performance, branching programs provide remediation or enrichment activities. These tests are usually multiple choice, matching, true-false or short answer (such as math problem answers). The programs record the child's responses, grade them and give feedback both to the child and the teacher. The teacher feedback may include statistics such as class averages, standard deviations or which questions were missed most frequently.

Other programs are available to help create, administer, score and maintain records of teacher-made test (such as Learning System by Micro Lab, or Telefacts by dilithium Press). Such programs allow the student to take tests with immediate corrective feedback for instructional purposes or with corrective feedback at the end of the exercise when used as a test. Using the test as an instructional aid, the student gets multiple chances to answer correctly, receiving feedback on each response and finally receiving the correct answer if needed. When used for testing, the student is informed at the end of the test of the number of right and wrong responses, and receives corrective feedback on wrong responses. The program keeps track of errors, notes the nature of the error, computes individual and group statistics, and stores this information for later use by student and teacher.

One unique program under development (Ray, 1982) is a computerized WISC-R protocol. Rather than write responses on the protocol, they can be entered directly into the computer (a small portable one). Each response can be scored immediately or later. The program offers prompts for determining basal and ceiling levels. At the conclusion of the testing session, the computer will produce the standard scores based on the information entered. Verbal subtests that require subjective scoring must be scored by the examiner but help screens provide scoring criteria from the WISC-R manual. It remains to be seen whether typing in answers is faster and more accurate than writing them, and whether computer use is a distracting factor interfering with the testing situation and the individual's performance.

Most computer-administered tests are for adult populations. They include personality inventories and vocational or interest inventories. Some hardware is specifically designed for test-taking; the keyboards have been modified so that there are just a few keys to minimize confusion. Tests in a multiple choice or forced choice format are readily adapted to computerized administration. Most tests administered by computer are paper and pencil tests entered into the computer data bank. Few tests have been developed especially for computerized assessment purposes, making full use of the computer capabilities. The few that exist are primarily used for adult clinical populations and for research purposes (Klingler, Miller, Johnson, and Williams, 1977; Psyc-Systems, 1984). Very few computer-administered tests have norms based on computer administration. Most use the paper-pencil norms that were developed with the original tests.

Test administration is a controversial area in school psychology computer applications. Some practitioners view computerized test administration as a threat to job security rather than as an opportunity to enlarge the possibilities for service. Research is needed to determine the reality of this perceived threat. Research is also needed to identify differences between computer-administered tests and practitioner-administered tests, and to develop computer-administered norms. Studies have shown people to be more open and honest when responding to computer questions than when responding to a human interviewer (Evans, 1979; Quintanar, Crowell and Pryor, 1982). Whether the computer is a distracting and interfering factor or an enhancing one remains to be shown.

Test Scoring

Test scoring involves identifying responses as correct or incorrect, computing raw scores for each subtest of a battery and then converting the raw scores to standard scores using norm tables prepared by the publisher/researcher. Some test batteries may be easily scored by computer because each response is clearly right or wrong, or is clearly part of one category or another. For example, arithmetic answers or answers on a rating scale have distinct and limited responses. These responses may be entered into the computer either directly by the examinee (if the test has been adapted to computer presentation) or later by the examiner. The computer tabulates the score and converts it to the appropriate standard score. Other subtests require subjective scoring by the examiner, who may have to decide if the response is acceptable given certain parameters. For instance, the young child's language should not penalize the score, and judgment is frequently necessary to determine correct responses. Gestures may have accompanied the response to make it more correct than incorrect, for example. The response may also receive a varying amount of credit depending upon the response's nature -- concrete or abstract.

Examples of these kinds of tests include achievement batteries and intelligence tests that involve verbal responses. For these tests the examiner must compute the raw score for each subtest manually. Then the raw scores are entered into the computer, which converts them into standard scores and may provide other statistical information as well, such as standard deviations, stanines, percentage of the population obtaining such scores, etc. (e.g., WISC-R, Woodcock-Johnson Psychoeducational Battery, Peabody Individual Achievement Test, Kaufman-Assessment Battery for Children, and others).

Test scoring programs depend on the examiner (or a clerk) to type in raw data. Thus, individual subtests have to be scored in the traditional manner. The computer then displays the standardized scores accurately and in seconds. In some cases the standard scores are accompanied by a written analysis of the scores. In other cases a description of what the test measures is accompanied by a discussion of subject performance compared to the norm group and compared to him/herself.

Quality varies considerably among test scoring programs and one is advised to try the program for a 30-day trial period and to obtain representative printouts of the program before purchasing. Following are some considerations for judging a scoring program:

* Some programs can score multiple protocols at one time while others can do only one at a time. Time is saved if more than one school psychologist scores tests with the program or if there is frequently more than one protocol to score at one time.

* Some programs score more than one type of test; for instance, the WISC-R, the Wide-Range Achievement Test and the Vinelane Adaptive Behavior Scale. There may be a choice of tests to use in any combination or there may be no way to use the program without using all of the specific tests in the scoring program.

* Scoring programs that score multiple types of tests may also offer cross-test analysis and comparison. Research and statistical bases for these comparisons should be clearly explained and referenced.

* Scoring and cross-test comparisons should also follow psychometrically correct procedures. That is, grade-equivalents should not be compared with standard scores, and grade or age equivalents should not be reported when it is inappropriate to do so (not substantiated by the test construction and standardization procedures).

* Some scoring programs require that all subtests be given in order to score the test. Others can compute scores on selected subtests. Appropriate statistics should accompany partial administrations; if it is not possible to obtain a full-scale score with only a partial administration of the test, then a full-scale score should not be reported.

* Printouts should be easy to read and contain all relevant information. There should be a reminder printed that the test data must be interpreted by a professional trained to do so and that the printout does not constitute a psychological report.

* It should be possible to send the scoring information to the screen or the printer.

* One desirable feature is the ability to transfer the data to another data management program for permanent storage. Then the data do not have to be entered into the computer a second time.

* The program itself should be technically sound. There should be: error correction capability; ability to go both backward and forward through screen presentations; visually well-planned screen presentations; clear data entry procedures; and screen notification during data computations (not just a blank screen).

Let the buyer beware is the best advice to follow. It is also not a bad idea to randomly check the program for accuracy in scoring. There is always a possibility of typing errors in a program. (If such a bug is discovered, notify the seller/developer. Bugs can be fixed once they are found.) The above guidelines apply to test-scoring programs designed for individually administered, norm-referenced tests. Computer scoring programs also exist for group tests such as the Iowa Test of Basic Skills or the California Test of Basic Skills, but generally these programs run on mini or mainframe computers in regional or national locations and are machine scored from "bubble" answer sheets. Information on these types of scoring programs can best be obtained from the publishers.

Test Analysis

Once tests have been administered and scored, it is necessary to interpret the results in a meaningful way; to analyze and synthesize the results within the context of the referral problem. Interpretation is necessarily a subjective task that is unique to each individual tested. Basic guidelines are available from research and psychological theory, but the human element changes the interpretation for each individual.

Test-analysis programs have been produced by commercial publishers as well as by school psychologists for their own personal use (McCullough, 1982). These programs usually have a particular theoretical orientation that is used to analyze data from a specific test or tests. For example, WISC-R analyses are available using the Sattler, Kaufman, Lutey and other statistical methods of interpretation. These analyses vary in the approach taken to interpret the data, with each approach supported to some extent by research. For instance, one author may emphasize subtest-by-subtest interpretation. Another may emphasize groupings of subtests based on statistical correlations. Yet another may focus solely on full-scale, verbal and performance standard scores, ignoring individual subtest performance. In actual practice, a variety of interpretive approaches may be used depending upon the nature of the data and the training of the school psychologist.

Potential users should obtain a printout of a sample analysis before purchasing the program to check their agreement with the theoretical orientation and the programmer's interpretation of that orientation. It should be noted that not every permutation of scores can be programmed into the computer. The programmer made decisions about what were likely to be the most common patterns of scores and the most common interpretations of these patterns. It is the school psychologist's responsibility to use these programs with their own professional judgment always being the key to appropriate interpretation of scores. If nearly every individual is labeled learning disabled or schizophrenic by the program, there is probably a very narrow range of patterns and

interpretations programmed. This relates to another point: These programs should only offer **hypotheses** to consider as potential interpretations of the data. Nothing in the program or printout should lead one to believe the program is the final word on the individual's performance.

As with test-scoring programs, quality varies on organization, print format and various content factors. These programs can be used as screen or hard copy programs; the analysis can be read on the video monitor or printed on paper. Some of the programs tend to be detailed and wordy. Practitioners vary in their reports of how much these programs are used (McCullough, 1982) For some practitioners already familiar with the particular analysis, the program might be referred to infrequently. However, the program could prove valuable for an unusual profile or a need to review a particular interpretation. Other practitioners reported that the programs were used for nearly every analysis. Appendix A contains guidelines for evaluating test-analysis programs, including both blank forms and completed examples.

Test-analysis programs could be used for preservice or inservice training. Practice in interpreting various profiles would be possible. The programs could be used to introduce the different theoretical orientations as well as to provide repeated practice in learning to use them appropriately with a variety of presenting problems. Since professional skills tend to slip a bit as the years go by, these programs could serve well as a continuing professional development exercise. New methods of interpretation could be studied or more familiar ones reviewed and updated. One value of the programs is in the generation of several hypotheses to be considered in conjunction with other observation and evaluation data. New hypotheses which might not have been considered without the analysis program are just as possible as valid rejection of irrelevant hypotheses.

Report Writing

Word processors abound in the marketplace. There are several kinds for each microcomputer. Cost and capability are closely related, so comparison shopping for "best buys" is advised. A psychological report may be prepared using a word processor, and a simple program is adequate. However, there are more complex programs with built-in dictionaries that help find spelling errors or allow more manipulations of the text files. Depending on whether the school psychologist is dictating the report for someone else to process, or typing the report directly on the word processor, the time to complete the report my be cut by 75 percent of what it was before using the computer (Baker, 1982).

There are several report-writing methods through which reports may be created with word processing programs. Typing text into a word processing program is similar to typing on a blank piece of paper except that the editing and memory capabilities make it easy to add, delete or modify the text without having to retype the entire report. Saving the report on a disk as a text file makes it possible to recall the document later and make changes or customize the report in a variety of ways. Parts of the report may be saved as separate text files and inserted into future reports or modified to reflect new information. It is possible to use the word processor to create reports "from scratch" or from pre-prepared text files. With the ease of revision offered by word processors, the way we think when we write is altered. Word processors allow limitless freedom to change, edit, erase or start over. A user can work on any section, move paragraphs around or do the introduction section last, all without putting anything on paper until it is just right.

Personalized report-writing programs have been designed as either "stand alone" programs or as text files on commonly used word processing programs (such

as AppleWriter or Executive Secretary) to make psychological report writing more efficient. Typically, these programs contain a means to insert certain phrases that are used frequently. For instance, if a section of the report describes the evaluation procedures used, this section is probably repeated in every report. To reduce repetitive work, the user stores the often repeated portion on a disk as a text file. Then when a report is written the user issues a command that tells the computer which prearranged phrases or text files to pull. The computer will insert those phrases into the designated section of the report. Some school psychologists store lists of recommendations that they frequently give; for instance, a description of a cognitive behavior modification technique. Then, instead of describing this technique each time it is referred to, the computer calls up the text file off the disk and inserts it where indicated. The typist has typed it only once, though it may be used in many reports. By using such word processing programs, most of the practitioner's time can be spent on the portions of the report that are unique to the referral. Personalized report writing programs can be genuine time savers.

Examples of some of these time-saving methods follow. Note the variations in the amount of standardization or customizing possible with the different methods. Also, note that a variety of report-writing styles exist in both practitioner developed and commercially developed personalized report writing programs. It would be wise to obtain a sample print-out of the files in the program before purchasing it.

***Form Text:** Reports are created with routinely used blocks of text. This method is similar to filling in the blanks on a form. The text is repetitive, consistent and standard for all readers; no attempt is made to individualize the information for specific readers. The form text is supplemented by the addition of information related to the case in much the same way as a form is filled in at the space where lines occur.

An example might be a paragraph describing an assessment measure used, followed by the scores achieved on that measure:

> **Cognitive Abilities Assessment**
> The Wechsler Intelligence Scale for Children, Revised (WISC-R) was administered. The WISC-R measures verbal and non-verbal problem solving skills using a variety of tasks. Standard scores and percentiles allow comparison with children the same age using national norms on three primary scales: Verbal, Performance and Full Scale (a combined score form the Verbal and Performance scores). The results of this assessment are:
>
> WISC-R
>
> Verbal Scale IQ = percentile
>
> Performance Scale IQ = percentile
>
> Full Scale IQ = percentile

The typist would merely insert appropriate scores when queried by the program. The text would not be altered.

***Report Generators:** Report-generator programs may produce a form text-type of report from data entered into the computer either directly from taking tests on the computer or from raw data entered by a clerk. Typically, little or no information regarding behavioral, observational or clinical variables is considered. The report is primarily based on test data. A report generator is a depersonalized compilation of data, a report of scores. Frequently, the data are presented in charts or graphs. No attempt is made to interpret the data or to account for behavioral or motivational influences on the scores. Only cursory descriptions of test results may appear. Frequently these report formats are part of larger programs, such as IEP development or maintenance programs. If this type of reporting of evaluation information is the only type available, it would appear to be in violation of ethical standards since assessment information should not be shared without accompanying professional interpretation which takes environmental and behavioral factors into account.

***Customized Insert Standardized Text:** Some word processing programs allow building a set of customized commands which can be user defined. Special markers within a standardized text format allow insertion of customized information unique to the report. For example, suppose the customized common "C1" is defined as "child's first name." Any time there is a reference to the student by first name, the word processing program inserts the information specified in the customized command into the specially marked place in the standard text format. It is possible to create any customized command desired, to define innumerable questions in any manner. for instance, CC8 = Primary concern expressed is. . .or CC18 = Teacher-reported social functioning is (average, above average, below average). Parts of the report will be repetitive, consistent and standard across all reports with unique information inserted as needed.

Following is an example of customized insert standardized text. This represents how the text file might be sorted on the disk. When it is called up and each of the customized commands is defined specifically for this report, it will be the same for every student in some respects, but also customized more than the form text style.

Customized Standardized Text Computer Generated Psychological Report

Name: C1 & C2 Current Date: C5

School: C3 Parents: C6

Grade: C4 Address: C7

Reason for Referral

C1 was referred for evaluation because C8.

Evaluation Procedures

C9

C10

C11

C12

Result of this evaluation C13 considered to be a valid indication of C1's current functioning.

Customized Commands Defined

C1 child's first name

C2 child's last name

C3 child's school

C4 child's grade level

C5 test date

C6 parent's names

C7 child's address

C8 Primary concern expressed is:

C9-12 Specific evaluation procedures used:

C13 Reliable results?: (are/are not)

When using the customized format style of report writer, the typist is entering answers to the customized commands which are then inserted in the customized text file.

***Starter Text Files:** Starter text files refer to incomplete paragraphs related to a specific topic that have been stored on a computer disk and can be readily retrieved for inclusion in a report when needed. Starter text paragraphs provide a framework of frequently used blocks of text written by the professionals in their own style. A data base of text files can be built over time incorporating the most frequently used phrases or topics. Commercially prepared starter text files are also available to use as a base upon which to build (CAPER, Computer Assisted Psychoeducational Report Writer, Jackson County ESD, Medford, OR; School Psychology Text Files, Philip Bowser, Roseburg, OR). Content of the starter text files would be dependent upon the purpose of the report and the communication and organizational style of the writer. Some possible topics around which starter paragraphs could be built include: identifing information, referral concerns, background information and achievement of educational recommendations.

Starter text files must be modified to accommodate the uniqueness of the particular report. The double question marks in the example below represent places where information unique to this report would be inserted.

Starter Text File

Summary

Analysis of evaluation information indicated strengths in??. Skill areas needing improvement included??.

Completed Starter Text File

Analysis of evaluation information indicated strengths in math reasoning, perceptual analysis and synthesis of nonverbal problem solving. There was also improved impulsive behavior control under consistent, highly structured classroom settings. Skill areas needing improvement included peer social relationships, impulse control and spelling.

Starter text files provide a framework within which to structure the report. Since the text files are in the writer's own words and may be saved in several versions, variety and uniqueness across reports is possible.

School psychologists may not like to admit publicly that over time our reports do take on a repetitive style and begin to sound alike. But the reality is that there are parts of psychological reports that are repeated across subjects; e.g., demographic information, reason for referral, and brief explanations for evaluation procedures employed. Saving these sections as separate text files and then calling them off the disk as needed and modifying or changing them saves typing time (or dictating time) and allows the report to be completed sooner. Those who have used text files daily for report preparation state that their reports are longer and more complete and take significantly less time to prepare (Baker, 1982).

Data Management

Data management or record-keeping software has wide use and acceptance by educational administrators, teachers and school psychologists. Data can be compressed and stored electronically in large quantities. Data stored on computer diskettes may include:

* test scores
* psychological reports
* client daily contacts
* behavior intervention data
* actions and due dates
* scheduling information
* IEP goals and objectives
* address and phone lists
* budget projections and accounting, and many more.

The advantages of storing the information on diskette rather than in a paper file include:

* the accessibility of the information
* the speed with which it may be located
* the extent to which it may be joined with other information to create reports.

For example, quarterly reports to schools or districts served, or progress reports to teachers or parents could be prepared relatively quickly from data already stored in the computer.

Commercially available data base software can be adapted to a variety of specialized uses for school psychologists. Such software allows the user to define what kind of files are going to be stored and how they will be organized. In essence, a personalized filing system is being established. The uniqueness of the computerized filing system lies not only in its storage capacity, but in what can be done to the data once it is in the files. Files can be indexed in any manner desired, e.g., alphabetically, by zip code or other code, etc. Any numerical data contained in the files can by manipulated by the user (within the limits of the data base program in use). For instance, means, standard deviations or other statistical operations can be done with the data. When information is added to already existing files, the computer automatically updates these indexes or mathematical operations, if so desired.

Thus a typical file might contain information on clients, various therapeutic interventions, behavioral intervention data or evaluation data. The practitioner would have instant access to any file and could easily update,

delete or reorganize the data contained within. For instance, perhaps the school psychologist would like to see if there are any patterns emerging with children identified as learning disabled at a particular school or grade level. The data base program would search through the files and produce such information in a few seconds.

Data management programs have been used in the monitoring of behavioral intervention data (Grimes and Ross-Reynolds, 1981). The effectiveness of intervention data is immediately available. Further, the program can be designed to provide reminders to check on interventions that are in progress. The school psychologist would then know the behavior level as of the last check, what intervention was in progress, and the nature of the referring problem. When several interventions are being monitored simultaneously, such information can be useful.

Other uses for data management programs include maintaining inventory records or creating and maintaining IEP records. Whatever information needs to be stored and accessed, maintained, modified, updated, indexed, sorted into different categories or placed into any kind of a report can be managed by a data management program.

Comparison shopping is again recommended. Each microcomputer has several data base programs available for it. They vary in how big files can be, how easy it is to set up and update files, the kind of searches possible, the speed with which they operate, the kind and size of reports generated, and the kind of arithmetic operations it is possible to perform on the data. Template programs have been designed by some school psychologists to accompany some of the more common data base programs available commercially (e.g. PFS, Visifile, or DB Master). Templates are like blank forms ready to be filled in by the user. They save the development time necessary to set up a file on a data management program. For example, below is a simple Client Daily Report form used on PFS (Personal Filing System) software to record daily contacts with students, teachers, parents, administrators or agencies. It is sorted to produce quarterly reports for school districts, weekly reminders of actions needed, and student behavioral updates.

Clients Daily Record

Computer Form#_____ LSP Staff_____ Regarding Code_____

District: Bethel 5___ Blachly 90___ Creswell 40___ CAL___
Eugene 4J___ F. Ridge 28J___ J. City 69___ Lowell 71___
Mapleton 32__ Marcola 79J___ Mckenzie 68___ Oakridge 76__
P. Hill 1___ Siuslaw 97J___ S. Lane 45J3___ Springfield 19___
ESD___ Other_____

School/Agency_____ Date _____

Contact Person's First Name_____ Last Name_____

Student's First Name_____ Last Name_____

Contact Mode: Phone___ Letter___ In person___ Memo___ Confidential___

Notes:

Due Date Actions

Regarding Codes:

01 Student	02 Family	03 District
11 Meeting	12 Meeting	13 Meeting
21 Transportation	22 Transportation	23 Transportation
31 Counseling-Individual	32 Counseling-Individual	53 Outdoor Program
31G Counseling-Group	32G Counseling-Group	93 Other
41 Warm Fuzzies	52 Outdoor Program	
51 Outdoor Program	92 Other	
91 Other		

Research and Statistics

Large mainframe computers were used for research purposes in education long before the advent of microcomputers. With microcomputers many of the capabilities of the large computers are now available to practitioners. Statistical packages are available for the various microcomputers. For example, if a school psychologist wanted to develop some local norms for a particular instrument, a statistical package that offered correlations, analyses of variance or other more complex statistics would perform the operations on the data. These statistical programs vary in content, speed of calculations and quality. They may also vary in memory storage capability, limiting the amount of data that may be manipulated. Again, many school psychology computer users have also developed their own statistical programs to fit their own needs. For large amounts of data, mainframe computers are still the first choice.

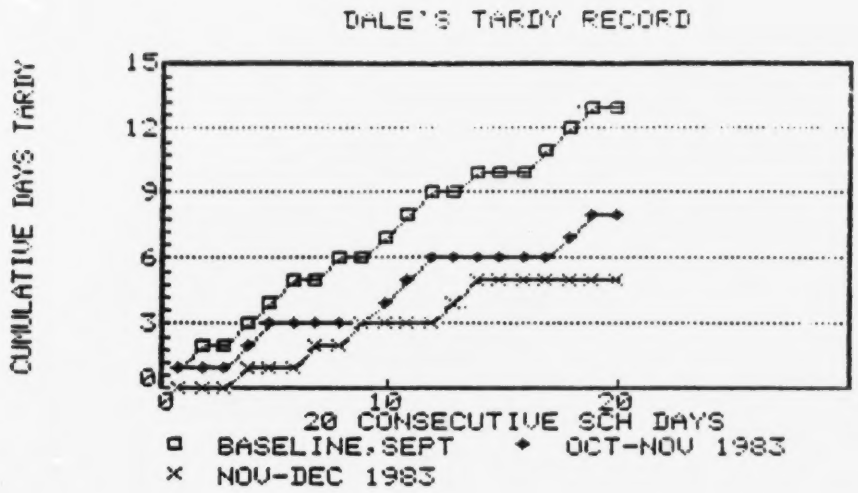
Some commercially available programs, such as Visicalc or Supercalc, allow complex manipulation of data and also have predictive capabilities. These are spreadsheet programs, designed for accounting and business purposes but adaptable to a variety of uses. For example, one school psychologist set up a "behavior bank" on Visicalc. The students made payments and withdrawals to their accounts based on the "pay" they earned in class. It was easy to make predictions for each student, given different scenarios for ending up with different amounts of "pay." For example, suppose it took 100 points to earn a field trip and the student had six days to earn it. How many points does s/he need to save or earn each day to make it?

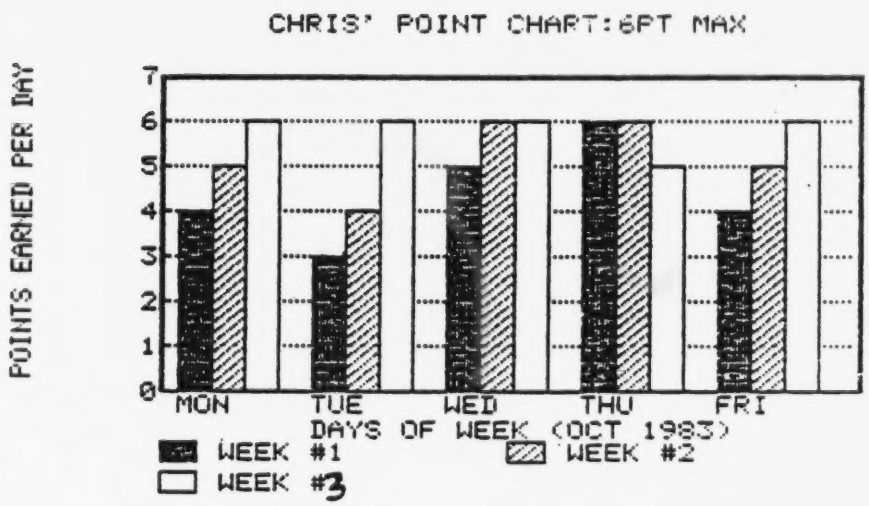
Microcomputers open up the world of research to practitioners. When data base programs are used to store data, it is relatively easy to sort the data along differing classifications. A descriptive study emerges rather easily. In addition, the data may be transferred electronically to a graphing program to provide descriptive graphs of the data. School psychologists have used these capabilities to graph behavior intervention results, comparisons among test scores over time and comparison scores between peers. (See graphs on following pages.)

Experimental research is also facilitated by microcomputer technology. Microcomputers can be used to present various kinds of stimuli and to collect response data. Microcomputers offer the possibility of observing behavior in a relatively controlled setting. That is, when observing an individual in a classroom, setting the referred behaviors may or may not occur. Situations may be set up on the computer to increase the likelihood of observing a given behavior: for instance, response time latency, eye-hand coordination, perceptual skills, etc. Given appropriate software, analysis of the data follows easily.

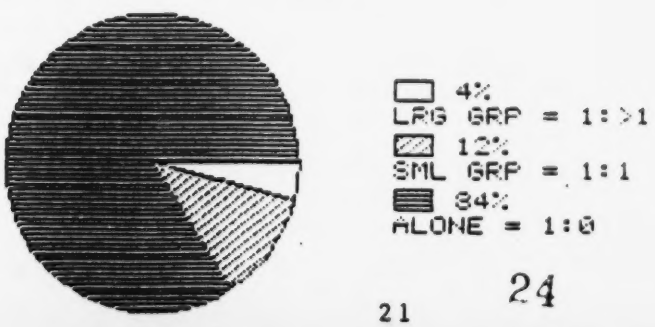
Time Management

Some administrators want to know how school psychologists spend their time. Time management programs assist in this process. Data can either be entered directly into the computer or put on coded cards for a clerk to enter. Categories of tasks related to the school psychologist's job description are determined, such as consulting with teachers, testing, observing, etc. Then amounts of time spent in each task can be noted. The reports generated by the computer can then be easily accessed by an administrator. Specific programs are available to do this task but data base programs could also be used (McCullough, 1982).

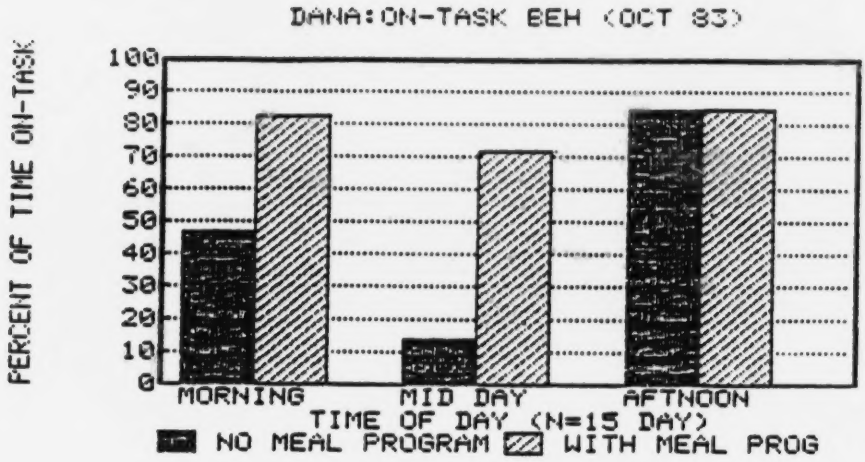


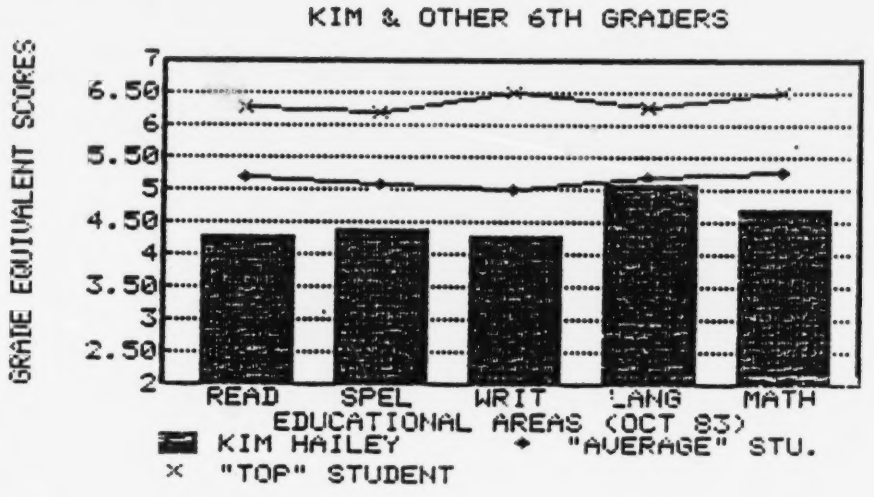


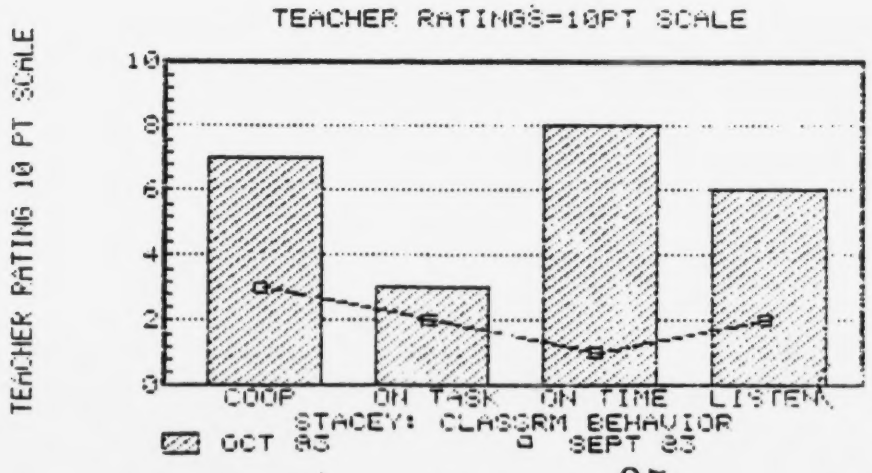
ERIN SOCIAL BEH AT RECESS
SOCIAL INTERACTIONS OCT83

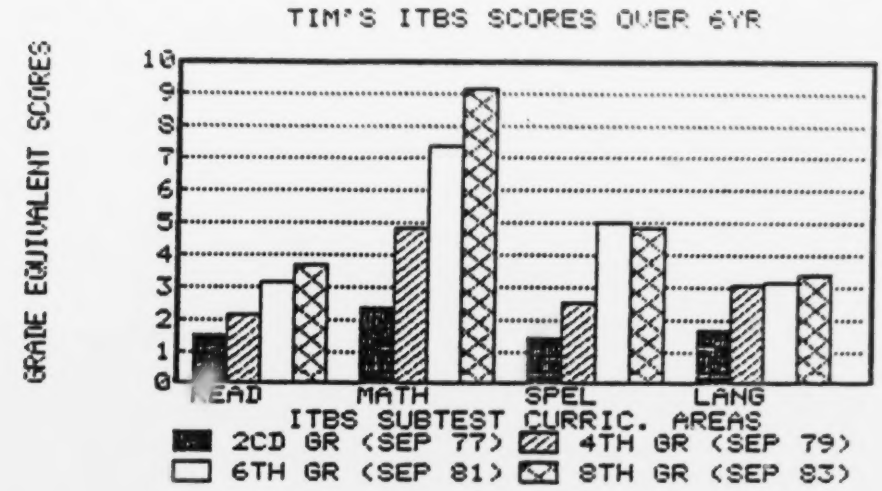


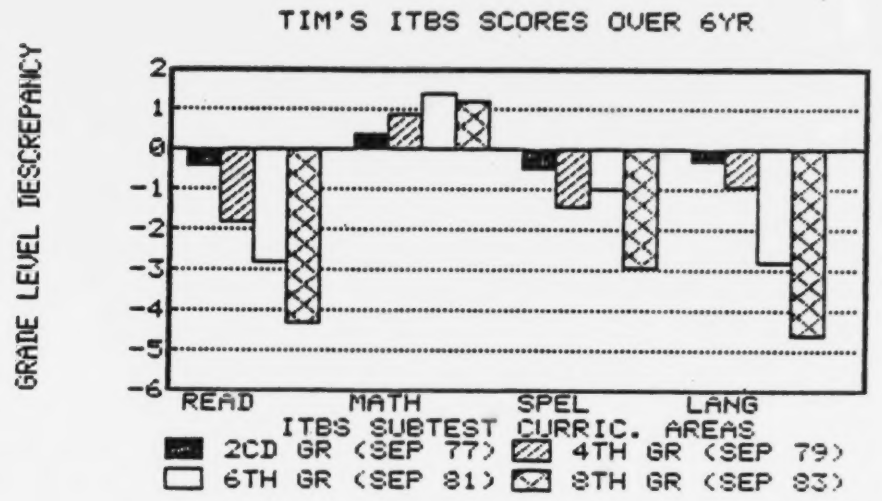
24

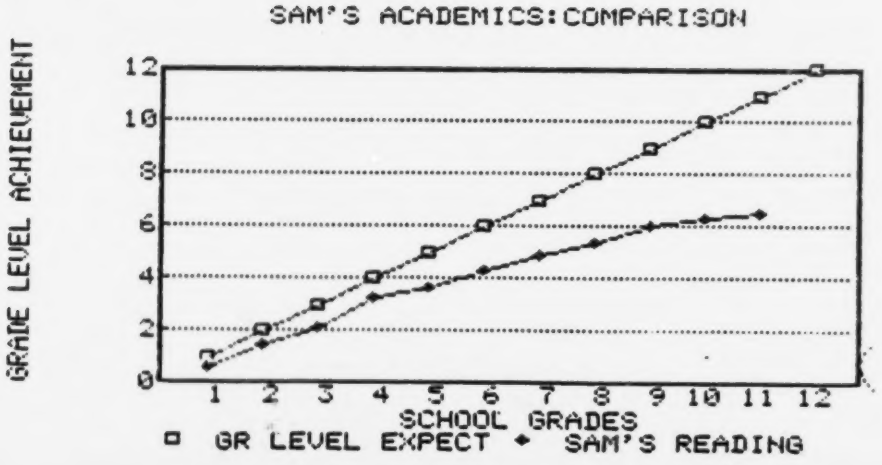

DANA:ON-TASK BEH (OCT 83)
PERCENT OF TIME ON-TASK
100
90
80
70
60
50
40
30
20
10
0
MORNING
MID DAY
AFTNOON
TIME OF DAY (N=15 DAY)
NO MEAL PROGRAM
WITH MEAL PROG


KIM & OTHER 6TH GRADERS
GRADE EQUIVALENT SCORES
7
6.50
6
5.50
5
4.50
4
3.50
3
2.50
2
READ
SPEL
WRIT
LANG
MATH
EDUCATIONAL AREAS (OCT 83)
KIM HAILEY
"AVERAGE" STU.
"TOP" STUDENT


TEACHER RATINGS=10PT SCALE
TEACHER RATING 10 PT SCALE
10
8
6
4
2
0
COOP
ON TASK
ON TIME
LISTEN
STACEY: CLASSRM BEHAVIOR
OCT 83
SEPT 83


TIM'S ITBS SCORES OVER 6YR
GRADE EQUIVALENT SCORES
10
9
8
7
6
5
4
3
2
1
0
READ
MATH
SPEL
LANG
ITBS SUBTEST CURRIC. AREAS
2CD GR (SEP 77)
4TH GR (SEP 79)
6TH GR (SEP 81)
8TH GR (SEP 83)


TIM'S ITBS SCORES OVER 6YR
GRADE LEVEL DESCREPANCY
2
1
0
-1
-2
-3
-4
-5
-6
READ
MATH
SPEL
LANG
ITBS SUBTEST CURRIC. AREAS
2CD GR (SEP 77)
4TH GR (SEP 79)
6TH GR (SEP 81)
8TH GR (SEP 83)


SAM'S ACADEMICS:COMPARISON
GRADE LEVEL ACHIEVEMENT
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12
SCHOOL GRADES
GR LEVEL EXPECT
SAM'S READING

Networks

Large computer telecommunication networks provide current information and instant communication among users. To use the network, access to a computer terminal, microcomputer or word processor with telephone communication capabilities is needed. By dialing a phone number, a direct connection to a computer is established which then allows messages to be sent or received. Networks include the following services:

* Electronic mail - personal correspondence between individuals and groups;

* Electronic bulletin boards - up-to-the-minute information on key topics of interest to users, usually maintained and updated by specific groups or individuals; and

* Data collection and information management systems -- computer based tools for conducting surveys and storing/analyzing information.

One network of interest to school psychologists is SpecialNet, established by the National Association of State Directors of Special Education (NASDSE). Subscribers to SpecialNet include a nationwide network of educators, resource organizations, advocacy groups, parents and others interested in special education. SpecialNet has numerous bulletin boards including:

1. **Federal** — daily updates on activities in Washington, DC, that concern special education (maintained by NASDE).

2. **Litigation** — brief descriptions of court cases and hearing decisions with references to assist the reader in obtaining in-depth information on particular cases (maintained by Education for the Handicapped Law Report, EHLR).

3. **RFP** -- a listing of requests for proposals and grants that relate to special education (maintained by NASDE).

4. **Early Childhood** — information pertaining to services for handicapped children from 0-8 years of age; subscribers post messages on this board.

5. **Employment** — listing of employment opportunities in special education; any subscriber can send employment announcements to this bulletin board.

6. **Conference** — listing of special education-related conferences; any subscriber can post an announcement.

7. **Multihandicapped** — information on administrative and instructional services for severely and multiply handicapped students (maintained by the Teaching Research Division of the Oregon State System of Higher Education).

8. **Computer** — information on computer applications in special education (maintained by Education Turnkey Systems, Falls Church, VA, though any sub scriber can also send a message to this board).

9. **Practices** — promising practices from around the nation regarding the provision of services for handicapped students are described: any subscriber can submit information.

10. Policy -- designed to assist state and local education agencies in developing or revising policies related to PL 94-142 and Section 504; Information is provided by Long and Silverstein, P.C., a Washington, DC, law firm (NASDE, 1982).

The above is a partial listing of the bulletin boards available on SpecialNet. Recently, the National Association of School Psychologists joined the network and has established a school psychology bulletin board. Bulletin boards contain public information. Thus on the NASP Bulletin Board is information specifically for school psychologists about current workshops, conferences, government actions, promising practices, pleas for help, job information, etc. For private messages or correspondence, the electronic mail capabilities are used. SpecialNet may cost less than conventional mail or long distance telephone calls, depending on its usage. It is possible to print out the information received or to view it on the screen. There is a subscription fee to join (presently $200), plus telephone connect charges for each use (ranging from $7 to $15 per hour of connect time, depending on the time of day). For further information, contact:

National Association of
State Directors of Special Education
1201 16th Street, N.W., Suite 404E
Washington, DC 20036
Telephone 202/822-7933

Other networks are also available with similar capabilities and new ones may emerge from other national organizations such as the American Psychological Association. For now, SpecialNet appears to meet some of the needs of school psychologists, especially now that NASP has become a subscriber and contributor. Since school psychologists also have ties to regular education and psychology, other networks established within those fields will also be of value.

Several state educational agencies have established their own intrastate networks. These include Illinois, Oregon, South Carolina, Pennsylvania, California, Minnesota, Wisconsin, Kansas, Florida and Utah. These state networks offer many of the same services as the national networks; that is, electronic mail and bulletin boards. In addition, through these state networks the large data base organizations can be accessed and searched for specific information. For example, the Illinois Resource and Dissemination Network (IRDN) supplies Illinois educators with education literature, projects, programs and consultants. IRDN includes a Promising Practices File (PPF) and Human Resources Files (HRF). The PLATO system is used for searching state resources files online. Also, IRDN uses data bases from Lockheed/DIALOG ERIC, and Bibliographic Reference Service (BRS). DIALOG, BRS, and ERIC are enormous data banks of published and non-published information from a multitude of content areas. Using key words the data banks can be searched for information on a specific topic. These data bases are discussed in a later section of this chapter. Another use of the state networks is record keeping functions. When the Local Education Agencies store their required student data on computers, the necessary state reports are easily sorted and filed over the state computer network. Savings in time and paperwork are great (NASDE, 1981).

Still another use for the state networks is that pioneered by the Minnesota Educational Computing Consortium (MECC). MECC began as a statewide

instructional time-sharing network which served as a tool for classroom instruction. By using the MECC network there was less need for each school district to invest in software that was also used throughout the state. Through time-sharing on the MECC system, each school has access to over 950 programs in the system. Apple or Atari computers with modems are in most classrooms throughout the state. MECC is now one of the largest producers and marketers of educational software, and continues to serve the Minnesota classrooms through its computer network.

Computer Assisted Instruction
Computer Managed Instruction

School psychologists must have knowledge of curriculum innovations and effective remediation strategies since our most frequent clients are children with learning problems who are not succeeding with normal classroom techniques. One such innovation is educational software for microcomputers. Software is being integrated into or added to the curriculum with or without thought to its place in the scope and sequence of the curriculum, its effectiveness in teaching concepts, its impact on children with learning problems or its remediation possibilities or limitations (Metzger, 1983).

It is beyond the scope of this monograph to detail the wide variety of instructional software available. Numerous reviews are available in such publications as The Computing Teacher, Software Review and Journal of Computer-Based Instruction. Local, regional and state workshops on computer assisted instruction and evaluation of software occurr nationwide. Evaluation workshops usually focus on technical qualities and educational appropriateness of software. School psychologists might want to evaluate the software for characteristics that make it appropriate or inappropriate to use with children with specific learning disabilities. For instance, a program with screen presentations crowded with specific words or distracting visual effects might prove difficult for a reading disabled child to manage. A fast-moving arithmetic drill might not have a calming effect on an impulsive, hyperactive child. A simulation involving descriptive graphs may help a reading disabled child to grasp a concept.

Guidelines for evaluation of instructional software are available from:

International Council for Computers in Education (ICCE)
University of Oregon
1787 Agate Street
Eugene, OR 97403-1923

Since computer assisted instruction appears to have the potential to encourage individualized instruction, school psychologists would be well advised to become knowledgeable about the possibilities offered in this area. Computer-assisted programs could be incorporated into instructional recommendations for remediating learning problems, especially as more research emerges to determine their usefulness. Torrance (1981) has suggested that the microcomputer offers the potential to develop the entire brain, employing both left and right hemispheres.

Following is a brief description of how computers are being used now with a comparison to theories of whole-brained learning and thinking.

***Drill and Practice**

Computers become "electronic workbooks" to provide practice and reinforce concepts previously taught. Drill and practice may elicit either left or right cerebral hemisphere responses depending on how it is conducted. If it emphasizes the "big ideas" of the content area and involves imagery and visualization, it probably requires right hemishpere functions.

***Tutoring**

Computers can systematically present new information with branching options depending on the child's responses. This procedure emphasizes right hemisphere functioning. However, if logical, linear, sequential processing were emphasized, it would call for left hemisphere processing.

***Simulations and Games**

Students are presented with alternatives by the computer and manipulate certain variables to produce desired outcomes. Both left and right hemisphere functions are used when students predict, estimate, judge the reasonableness of an answer and perhaps work with graphs, charts and pictures.

***Information Retrieval**

Information retrieval as part of computer assisted instruction is generally associated with left hemisphere functioning. However, it depends on how the information is presented and how it is processed after it is received.

***Problem Solving**

Using the computer as a powerful calculator or a creative medium for developing programs of various kinds can provide practice in integrated whole-brained functioning.

Computer managed instruction (CMI) is often paired with computer assisted instruction. CMI includes record-keeping and instructional management programs. CMI programs keep track of errors, report this information to the teacher and the student, if desired, and direct the student to practice items needing review. Percentages of correct items or other arithmetic calculations are also computed. In essence, the CMI program becomes an electronic grade book, keeping track of more details than possible with conventional means. After making back-up copies to protect the data, the old green gradebooks can be thrown out.

School psychologists may be called upon to help interpret the mass of data that can be collected by CMI programs. Error analysis skills and statistical manipulation of the data may be required. Further, school psychologists could interpret the implications of the data for individualized program planning. The criterion-referenced nature of the data could serve as a starting or ending point when considering additional evaluation.

Career Guidance

Computerized career guidance programs are available commercially. These programs can be linked to vocational or interest inventories. The interests of

the student are compared to interests expressed by people employed in various occupations. Employment opportunities within various professions or trades, expected educational or skill levels and expected salary or income information is also available. Detailed information on colleges and universities is also available and can be matched to the student's interests. This information can give the student a realistic picture of the expectations of various job and educational opportunities. It provides factual information upon which to base decisions. Below is an example of a printout from a career information service program.

```
#8: PGM=*CIS
HELLO!

   CIS' FALL 1984 UPDATE TAPE HAS BEEN LOADED.   PLEASE CHECK TO BE SURE YOU ARE
USING A BROWN COMPUTER USER'S HANDBOOK.

PLEASE ENTER YOUR NAME, THEN PRESS THE 'RETURN' KEY.
GARY
HELLO GARY,
YOU ARE LOGGED IN TO THE CAREER INFORMATION SYSTEM.
HOW DO YOU WANT TO START?
IF YOU FILLED OUT THE QUESTIONNAIRE IN YOUR HANDBOOK, TYPE IN:  QUEST
IF THERE ARE OCCUPATIONS,  EDUCATIONAL PROGRAMS, OR SCHOOLS YOU WANT INFORMATION
ABOUT, TYPE IN:  INFO
INFO
FOUR KINDS OF INFORMATION ARE STORED IN THE COMPUTER:
- - - OCCUPATIONS:   LOCAL, STATE, AND NATIONAL LABOR MARKET INFORMATION THAT IS
      CONTINUOUSLY UPDATED.
          TYPE  IN 'DESC' AND A 4-DIGIT OCCUPATION CODE (EXAMPLE:   DESC  2656).
          YOU  MAY  ALSO FIND OCCUPATIONAL  BIBLIOGRAPHIES  (BIB),  OCCUPATIONAL
          VISITS (VISIT),  OCCUPATIONAL CLUBS (CLUBS),  AND WAYS TO  PREPARE FOR
          OCCUPATIONS (PREP).   FOR HIGH SCHOOL SUBJECTS, TYPE IN;  'PREP' AND A
          2-DIGIT OCCUPATION CODE;  FOR EXAMPLE, PREP 26 FOR SCIENCE AND LABORA-
          TORY OCCUPATIONS.

- - - JOB SEARCH.
          TYPE:  EMPL 1000
- - - PROGRAMS OF STUDY AND TRAINING:  TYPICAL COURSE WORK AND LIST OF SCHOOLS.
          TYPE IN 'PROG' AND A 3-DIGIT PROGRAM CODE
          EXAMPLE:  PROG 369
- - - SCHOOLS:
      SERVICES AND COSTS OF SCHOOLS.
          TYPE:  SCH
      FINANCIAL AID
          TYPE:  FINAID
YOU CAN FIND CODE LISTS IN YOUR HANDBOOK.

EXAMPLE 8434
  8434 PSYCHOLOGISTS

THERE IS NO EMPLOYER INDEX INFORMATION AVAILABLE FOR THIS OCCUPATION.
FOR A LIST OF AVAILABLE INFORMATION, TYPE IN:  INFO 8434
```

```
INFO 8434
WHICH AREA:                    TYPE:
NORTH OR SOUTH COAST             CST
LANE COUNTY                      LANE
PORTLAND METRO AREA              PORT
EAST OF CASCADES                 EAST
MID-WILLAMETTE AREA              WILL
SOUTHERN OREGON                  SO
OTHER AREA                       OTHER
LANE
   8434  PSYCHOLOGISTS
FOR A DESCRIPTION OF THE OCCUPATION, TYPE IN:  DESC 8434
FOR WAYS TO PREPARE, TYPE IN:  PREP 8434
FOR BOOKS, TYPE IN:  BIB 8434
FOR THE NAME OF A PERSON TO CONTACT, TYPE IN:  VISIT 8434
YOU CAN ALSO GET INFORMATION ABOUT EDUCATION AND TRAINING PROGRAMS  (TYPE:   PROG)
AND SCHOOLS (TYPE:  SCH)

VISIT 8434
   8434  PSYCHOLOGISTS

PERSON TO CONTACT:                FIRM NAME:
DR. STERLING G. ELLSWORTH         PRIVATE PRACTICE
PSYCHOLOGIST                      HULT PLAZA--SUITE 4-C
PHONE:  342-6151                  401 EAST 10TH
SPECIAL INSTRUCTIONS:  CALL 342-6151 FOR AN APPOINTMENT
WILL ALSO TALK TO GROUPS IN EUGENE/SPRINGFIELD AREA
HOURS ARE 9-3, MONDAY-FRIDAY.
IS AVAILABLE FOR
   1/2 - 1 HOUR FOR STUDENT VISIT/INTERVIEW
   CLASSROOM SPEAKING

PERSON TO CONTACT:                FIRM NAME:
NANCY HAWKINS                     THE BEHAVIOR CHANGE CENTER
PSYCHOLOGIST                      1651 MAIN STREET
PHONE:  726-5563                  SPRINGFIELD
SPECIAL  INSTRUCTIONS:   PLEASE CALL FOR AN APPOINTMENT;  HOURS ARE  10:00-2:00,
THURSDAY AND FRIDAY.
IS AVAILABLE FOR:
    1/2 - 1 HOUR FOR STUDENT VISIT/INTERVIEW
```

Data Bases

Hundreds of large data base systems are commercially available (Kruzas and Schmittroth, 1981). Examples include ERIC (Educational Resources Information Center), which is available on BRS (Bibliographic Reference Service). These data bases contain tremendous amounts of information which can be retrieved through terminals anywhere, though it takes skill and training to obtain the information as efficiently and economically as possible.

A caution is in order. In libraries there are people skilled in interacting with the different data bases. Use them. The number of times access to a large data base is needed is limited, probably less than once or twice a year, if that much. It takes training and practice to know how to efficiently enter

the appropriate descriptors to get the output desired. Access time on the data bases is expensive (usually above $30 per hour). Wasting time and energy and getting expensive and irrelevant information as output is a very frustrating experience. In addition to online services, most data bases have numerous publications. Below are some examples of some of the online data bases of interest to school psychologists that are included in one large system:

Child Abuse and Neglect
Congressional Record
Exceptional Child Education Resources
Language and Language Behavior Abstracts
National Information Center
for Special Education Materials
National Information Center
for Education Materials
Psychological Abstracts
Social Science Research
US Public Schools Directory

Information contained in the data base may be two or three years old by the time it goes through the publication cycle and is entered into the data base. However, as a source of background and research information, these data bases are an invaluable research and professional tool. Some data base services contain data of a specific nature, e.g., math, reading and science data for children in grades four through six in 10 states since 1978. For a researcher interested in such data, that data base would offer a rich resource. Data base services may be purchased on a one-time use basis or by subscription.

Future Computer Applications

Making projections about the future of computers in school psychology is dangerous. Computer technology changes so rapidly that even computer scientists cannot keep up. It follows that there is necessarily a developmental delay in software. Thus, some of the applications described in this section have not been developed yet. The technology is available to do so, however. Other applications may be available but are not widely publicized or are not being published by their authors for a variety of reasons. Also, the following projections do not begin to exhaust the possibilities for the development of software and computer technology within the field of school psychology. This is an attempt to provide a data base--a beginning designed to stretch the imagination and creativity of the school psychology computer enthusiast.

Potentialities

1. Use computers and specialized computer programs as a form of therapy. Behaviorally deficient children could experiment with different solutions to problems and immediately experience the consequences of their choices through computer simulations. For example, using videodisc-computer combinations, common problem situations can be presented to the child. The child can decide the characters' ages, sexes and races and the setting and problem situation; for example, social interactions on the playground, including joining a group or requesting assistance. The computer would generate a scenario and interact with the child about possible solutions. The consequences of various choices would be presented. Use of videodisc technology allows interactive role playing in a secure, private setting. Such programs become interactive computer soap operas of sorts, with actors and actresses performing in situations that are directly related to the problems faced by the child. Such programs might also be used to teach social skills to handicapped children or younger children.

2. Collect and store behavior intervention data with data management programs, and then use the data to look at trait/intervention interactions. That is, to help predict what instruction will be beneficial to what children under what conditions. With the data readily accessible and easily organized in a variety of ways, school records can be put to better uses than filling filing cabinets or gracing yearly reports.

For example, drawing from aptitude-treatment interaction research (ATI), we could make predictions and plan interventions to make the best use of a child's strengths. We would have a data base to give us information about which interventions worked or did not work well in similar cases.

3. Use computers to help children learn subtle rule systems and problem solving strategies. When we do not follow the rules (such as giving an erroneous input message to the computer) we get error messages back and the system does not follow our directions. With guidance children might generalize this understanding to the larger world of social system rules. Programming computers also teaches children to break problems down into smaller chunks in order to understand them. Problem solving strategies needed to solve computer bugs might be generalized to solving other life problems.

One lesson that can be learned from computer programming is that it is all right to make a mistake. Frequently, children with learning problems or children pushed to achieve beyond their capabilities become fearful of making mistakes. They may refuse to respond or respond impulsively. As computer programs are debugged it becomes evident that the mistakes teach more about programming than about the capability of the student. Computer programs with bugs have to be debugged, before the program will run properly. And it seems as though computer programs always have bugs at first. Thus, programming provides practice in using problem solving strategies that are relevant and naturally rewarding.

4. Program computers to help analyze/diagnose problems. For instance, the medical profession uses computers to do intake interviews and to ascertain background information, medical histories, etc. The computer follows up responses to the questions with other questions. The physician then receives a tentative diagnosis or recommendations of tests to give or further information to ascertain, such as blood pressure, heart rate, etc. Studies have shown that people tend to be more honest when responding to computer questions than to an interviewer, no matter how sympathetic or experienced the interviewer may be (Evans, 1979). Using the computer to gain important background information from both parents and teachers could be not only a time-saver, but also a better source of information than current methods. Structured questions could elicit behavioral and academic information directly relevant to the reason for referral and aid in planning appropriate consultative or intervention techniques.

5. Establish a data base from practitioner's data that would describe children's behavior in different crisis situations. For instance, factors that seem most closely associated with separation anxiety or factors that emerge strongly in regard to school phobics could be culled from practitioners. Typical ages for universal crises, such as rejection by the best friend, could be determined. Through parent training or individual or small group interventions, preventative measures could be planned, possibly avoiding the anticipated crisis altogether.

6. Facilitate descriptive and longitudinal research by practitioners with microcomputers that can store and manipulate large amounts of data. Increased development of local norms and local profiles for learning disabled children would be possible. Identification of consistent problem areas in instruction and trends within local populations would be almost instantly possible with computerized data bases. For instance, if test profiles of learning disabled children reveal a significant proportion have difficulty with decoding skills, perhaps instructional techniques should be investigated.

7. Produce intervention effectiveness data that would be available to increase accuracy of recommended educational changes. For instance, the school psychologist could describe a problem behavior to the computer such as impulsive responding. The computer would then draw on its data base to describe some possible intervention strategies to the teachers/parents with the additional information that Plan A (a cognitive behavior modification strategy) has an 80 percent chance of success, Plan B (a token economy) has a 40 percent chance of success and Plan C (a computer simulation) has not been tried before. Computers could support psychoeducational recommendations with research-based information, unlike current practice.

8. Catalog the numerous resources that are often hidden away in the teacher's closets or are only used infrequently within a school district. A computerized listing of all the resources of the district and their location and projected usage schedule could more effectively distribute those resources among all the teachers and school psychologists who might need them. Thus if a school psychologist recommended a certain remediation strategy, information would be readily available as to whether the needed materials were available and where they would be found.

9. Increase communication among education professionals with computer telecommunication networks such as SpecialNet, or in-state education networks. Many telecommunication networks exist offering electronic mail and information of various kinds, including: stockmarket information, The New York Times and other newspapers, college courses, remedial reading courses and even shopping services. All of these are available by connecting the computer to a phone line and transmitting and receiving information electronically. A modem attached to the computer is necessary to transmit signals.

These computer networks offer public bulletin boards where announcements of classes, workshops, seminars and meetings of all kinds are announced. The bulletin boards may also contain notices of unlimited variety, for example: an offer to exchange a spelling program; someone looking for help with a particular programming bug; a users group announcing an event; or a researcher listing resources available to meet some specific need. The SpecialNet Federal bulletin board contains up-to-the-minute information on legal changes or announcements at the national level. State legislative bulletin boards contain equivalent information at the state level. School psychology bulletin boards could contain: information to share about new, useful materials; questions about a complex instructional problem; or exchanges of information about a child transferring from one district to another, etc. Through SpecialNet a school psychologist concerned about a multi-handicapped child could gain information about the latest research findings, suggestions for evaluation and remediation, and names of people to contact for further information.

Telecommunication networks also open up the limitless possibilities of electronic mail. Information is transmitted instantly. Documents can be shared without paper, envelopes or stamps. Communication among and between school psychologists can be greatly facilitated.

Telecommunication networks also offer the possibility of transmitting entire newsletters, journals and any kind of written communication over modem interfaces. Mailboxes may be found in antique shops one day rather than next to the front door.

10. Assess the impact of Computer Adapted Testing (CAT), an individually tailored evaluation system. Early versions are now being marketed that contain a data base of test items, for example in math and reading. A flexible number of items is selected from a large item pool to maximize matching of new items to the child's ability level as measured by preceding items. The child's basal and ceiling levels are established. Practice worksheets containing items not yet mastered may be produced with the program. Then the child may be retested with a new set of randomly produced items. In essence, CAT is criterion-referenced testing carried to its ultimate potential. At any point in time the achievement level of a child can be measured and compared to that child's previous achievement level. Since each test is unique to the child taking it, no two tests will be alike. Thus, classical test theory which emphasizes reliability, validity and estimation of true scores based on the total score for a test must

be thrown out and replaced by Item Characteristic Curve Theory (Tatsuoka and Birenbaum, 1981).

With computers in every classroom, computer adapted testing could be accomplished as frequently or infrequently as necessary. Knowing the child's level of achievement across several subject areas would immediately pinpoint where instruction should begin. Deficits or knowledge gaps would be apparent and individualized instruction planned.

Computer managed instruction (CMI), a related system, keeps track of errors as the child attempts a CAI program. It keeps records for the teacher on the number and type of errors and notifies the child of the same information, if desired. In addition, it can automatically provide additional practice over those items that were missed during instruction or skip the child ahead if the concepts are mastered.

With both CAT and CMI, the teacher can know exactly where the child is functioning and what areas of weakness need remediation. Still unanswered, however, is the question of whether all this information will help the teacher to teach more effectively or the child to learn more effectively. Research exists which suggests caution in assuming positive outcomes (Tatsuoka, K. and Birenbaum, M., 1981).

11. Incorporate "whole-brain," "no limits to learning" theory into assessment and remediation strategies (Torrance, 1981). Using traditional or computer assisted evaluation to determine hemisphericity (learning style), individualized instructional strategies could be planned using microcomputers. Figure 1 contains a list of specialized information processing preferences that have been associated with either right or left hemisphere functioning.

TABLE 1

From Torrance, E.P., Journal of Computer-Based Instruction. May 1981, Vol. 7, No. 4, 99-105

RIGHT HEMISPHERE FUNCTIONING	LEFT HEMISPHERE FUNCTIONING
--reading for main ideas	--reading for specific details
--searching for hidden possibilities, uncertainties	--searching for what we can be sure of, established truths
--recalling pictures and images	--recalling words, names, dates
--thinking of images, pictures	--generating word thoughts
--thinking intuitively	--thinking logically
--making predictions intuitively	--making predictions systematically
--dealing with several things systematically	--dealing with one thing at a time
--having sudden insights	--building a line of reasoning to a conclusion
--playful and loose in experimenting (cooking, research)	--systematic and controlled in experimenting
--writing fiction	--writing non-fiction
--being absentminded sometimes	--almost never absentminded
--watching and then trying to do it	--hearing verbal explanation and establishing a sequence of steps

--remembering facts picked up from things going on	--remembering only things specifically studied
--creating, improvising in hobby	--collecting things
--playing hunches	--betting on a sure thing
--organizing things to show relationships	--organizing things sequentially (time, size, importance, etc.)
--expressing feelings through poetry, song, dance, art	--expressing feelings in plain language
--remembering sounds, tones	--remembering verbal materials
--inventing things, procedures	--improving things, procedures
--drawing own images and ideas	--copying, filling in details
--listening to music while reading or studying	--getting things quiet while reading or studying
--learning from demonstrations	--learning from verbal descriptions
--learning experientially by doing	--learning through logical reasoning
--daydreaming	--planning realistically
--open ended instruction	--knowing exactly what to do
--responding positively to emotional appeals	--responding positively to logical appeals
--learning through exploration	--learning through examination
--learning geometry	--learning algebra
--using analogy and metaphor	--using plain language
--summarizing material studied	--outlining things studied
--remembering faces	--remembering names
--interpreting body language	--relying upon what people say
--approximating, estimating	--measuring with precision
--saying/doing humorous things	--saying/doing well reasoned things
--synthesizing ideas	--analyzing ideas
--improvising	--using the correct thing
--drawing, model building	--describing things verbally
--assuming	--verifying
--lying down and thinking	--sitting erect and thinking

Computer programs, including games and educational programs, exist that focus more on either left or right hemispheric functioning or combine both in the type of presentation and responses required. What would be the result of matching the child's preference with a "like-minded" computer program? What would be the result of using computer programs to provide practice in tasks that make use of both hemispheres?

Torrance (1981) points out that:

"...the weight of present evidence indicates that people fundamentally prefer to learn in creative ways--by exploring, manipulating, questioning, experimenting, risking, testing and modifying ideas....Current and traditional public school teaching strategies appeal to and develop primarily the left cerebral hemisphere through their heavy emphasis on language processes and on the logical, sequential processing of information....It is possible to modify a person's preferred style of learning and thinking over relatively brief periods of time (six to 10 weeks). Not only are changes possible, but it seems that the general direction of the changes can also be controlled....It may

become possible to train individuals to modify their information processing procedures to best fit the demands of their lives." (P. 101.)

12. Use computers to assess individual differences in acquisition and retention of new knowledge, focusing on process variables rather than product variables (Mitzel, 1981). For instance, computer simulations could assess rate of mastery under a variety of conditions, preferred modality, hemisphericity, or motivational factors. Computers may also provide a standardized setting in which to directly observe and measure time on task, eye-hand coordination, stimulus response time or problem solving skills. This information could then be used to plan individualized educational programs or behavioral interventions.

13. Use computers to develop new preservice and inservice training procedures. Present school psychology training procedures consist of trial and error procedures with real subjects in which the subjects are not always available when needed, the type of problem presented is unpredictable, it is difficult to check procedures and diagnoses, and incorrect diagnoses are possible at the expense of the subject. Computer simulations could be developed which not only presented realistic situations but also changed subject behavior to simulate the impact of the decisions made (Boysen and Thomas, 1979).

Simulations of problem behaviors or problem classroom settings could be programmed. The student would indicate the appropriate intervention strategy and receive immediate feedback on the effect of that strategy on the simulated problem. In assessment practicums (assuming these are still needed in the face of computer technology), similar simulations would have the computer act as a subject of a given ability level and age and produce responses for the student to evaluate. Immediate feedback could be given on the correctness of the student's choice.

Inservice training or continuing professional development courses could be offered using these same training materials. Using modem interfaces in one's home, office or in onsite training workshops, the practitioner could learn new techniques and new intervention strategies, retool on revised or new evaluation procedures, practice on the computer simulations, and then take a mastery test. CPD credits could be arranged for successful completion to the materials. Such arrangements are already in place within the medical profession.

14. Combine videodisc and computer technology to give yourself the power of television and the ability to show real people doing real things rather than animated simulations on computers. Combining the computer with the videodisc gives a formerly passive medium interactive capability. The programs can be stopped, modified, changed, questioned, begun again or skipped to another section. Branching programs are possible which can individualize instruction. Videodisc-computer programs have been developed for use with deaf children and have been found to be an effective teaching medium (Thorkildsen, 1982). Possible uses for school psychologists include:

* Consulting/counseling training -- for example, teaching intake and diagnostic interviewing skills;

* Counseling therapy -- for example, interactive role playing of problem situations with immediate feedback on the effects of proposed solutions to the problems;

* Parent training -- for example, interactive role playing and solution trials;

* Preservice and inservice training -- for example, simulations of problem situations such as scoring responses on the Verbal Scale of the WISC-R and achievement of mastery in assessment skills before introducing real subjects to test;

* Instructional interventions -- especially for children requiring emphasis on visual or multi-modal presentation of material, or numerous repetitions of a highly motivational nature; and

* Teaching and testing computerized assessment as a means to assess learning strengths and weaknesses -- for example, testing reaction speed, trials to success, visual-motor coordination or attention to task through responses to computer generated stimuli.

SUMMARY

Fourteen suggestions for future computer applications in school psychology do not exhaust the possibilities for the field. These ideas have been offered as starting points. School psychology as it exists today may not exist in the future. Computer technology can help expand our roles within the schools and the community. To paraphrase Seymour Papert, school psychologists can "adapt by transforming into something new or wither away and be replaced" (Papert, 1981).

Issues

As computers are incorporated more and more into the school psychologist's daily practice, we need to be aware of some potential problems and possibilities for abuse of the technology within the profession. The need for research in several areas related to computer applications is clearly a high priority. Issues relating to both current and future applications have been organized into four classifications:

*Professional Status;

*Ethical;

*Research; and

*Theoretical.

Professional Status Issues

Technophobia, or fear of technology, can creep in when computers appear. Technophobia may be caused by a fear of job elimination, of damaging the expensive equipment or simply of the unknown. In addition, a role change may be required, especially if computers are used in innovative ways and not just as fancy testing machines or electronic file cabinets. These fears can present realistic barriers to implementation of professional applications (Super, 1963). Instruction in the capabilities and limitations of computers and opportunities for interaction with computers tend to dispel these fears and thus should be provided (Kusnir, 1968).

The rigidity and memory capacity of the computer can lead to abuse. Suppose we are allowed 60 days from the time of referral to the time we should have an IEP on file or have disposed of the case. Or we are faced with the inevitable pile-up of referrals at the beginning of the year. Computer generated reminders may begin to appear on our desks. We may be required to file progress reports with the computer. Rigid enforcement of deadlines may seriously interfere with the professional performance of our job. Events like measles, snow days and the usual round of winter flu can cause delays which may not be acceptable to the nagging computer program.

Report-writing programs, which can be great timesavers, are beginning to emerge. But automated report generators may go too far. When all one has to do is type in the raw data and receive a "report," it is certain that the report will emphasize test scores and ignore interactions, motivations or behaviors that influence results. Fill-in-the-blanks reports help no one. If our goal is to help in the understanding of children's behavior, then we need to retain some control over report format, content and organization.

Using computers to score or administer tests will likely increase our efficiency. Will we then be expected to give more tests or to increase the number of children we assess? Or will we be able to use this "found time" to employ other skills, such as teacher or behavioral consultant, inservice trainer or researcher? The computer can be looked upon as an emancipator, freeing us of

routine, clerical tasks and allowing us to exercise the talents and numerous skills for which our training has prepared us.

Related to this problem is the possibility that administrators will look at the increased efficiency of computer-using school psychologists and choose to eliminate staff rather than use the current staff more effectively. NASP and state associations should be prepared for this situation to arise. Guidelines and principles for practice should be clear, well known and advocated by related professional groups.

As the quotation at the beginning of this section notes, some may fear that computer interviewing or computer assisted diagnosis and assessment may eventually lead to computer decision-making, thus replacing school psychologists. The fear is probably unfounded. Surrendering routine and time-consuming clerical tasks to a computer is not the same as hanging over matters of importance in children's lives. The interpretation that we give to the facts collected, the empathetic human interaction and the integration of all the different facets of each particular situation are still skills unique to a well-trained school psychologist. Computerization can offer our clients a higher quality time with us once we have become more than glorified records clerks.

Ethical Issues

Computer technology has been accepted so rapidly into the schools that research into the impact on children's behavior and learning has lagged behind. Ethical issues emerge when untried techniques are used without any guidelines available as to their effectiveness or impact on children. Ethical issues also arise with the increased storage of tremendous amounts of personal data. The ethical issues discussed here confront school psychologists now and demand attention.

Research requiring manipulation of data from huge data banks can lead to wrong conclusions. By doing a profile analysis on a group and then transferring generalizations about that group to individuals, we will encounter error. A related problem occurs when our profile analysis is derived from a restricted population and then generalized extensively to other populations. The parameters of a population must always be studied to determine if a particular subject would be a member of that superset. Extreme caution must be exercised when extending conclusions based on group data to an individual.

With so much data potentially available, privacy rights and protection of data from unscrupulous manipulation must be assured. Steps need to be taken to avoid selective manipulation to support a particular viewpoint. It should be pointed out that records stored in computer memory can be locked through a series of codes. In theory, electronic records should be more difficult to access than folders locked in a file cabinet. However, we need to control access to these codes before we can be assured that those who do use confidential data have ethical reasons for doing so. Ethical standards need to be developed and enforced. Professional research committees could screen applicants who wish to access the data, and file security could be a part of the computer literacy training of each school psychologist.

As noted, ethical problems may emerge as computer technology is implemented into the schools without adequate research available to provide implementation guidelines. For example, videodisc-computer behavior simulation programs offer a new therapeutic strategy. But research is needed to develop such programs and assess the impact on behavior. As with any behavioral intervention, ethical standards must be maintained. To use such potentially powerful programs to teach children only to be still, quiet, or "good little boys and girls," would violate ethical standards.

An ethical problem associated with computer software in general is copy-

right infringement. In standardized tests, for example, scoring tables and norms are copyright protected. To use them for commercial purposes in test scoring programs without the consent of the publisher of the test is unethical and unlawful.

The temptation is great to copy computer programs, especially those that are very expensive. The disk and documentation may not look like much for the hundreds of dollars charged, but they represent a large investment of time and money for the developer. Amateur programmers become reluctant to share programs they have developed because they soon find them all over the district with no reward for their efforts. As demand for computer software increases, production will increase and prices will come down. Nevertheless, copyright infringement is against the law and unethical.

Research Issues

Before our profession can embrace computer technology and attempt innovations in assessment and evaluation, instructional and behavioral interventions and record keeping functions, there are many questions yet to be answered:

> Is the computer a more efficient and effective teacher? Teaching machines ended up in the closet drawing dust; will computers share the same fate? What are the differences? How do we exploit the true potential of computer assisted instruction and not fall victim to the QWERTY principle?
>
> Does the machine distract or frighten some children? Are the mechanics too much for some children to master? What alterations are feasible or necessary?
>
> What age is optimal for computer instruction to begin? Should a computer language developed for children, such as Logo, make the assumption that the child knows how to read? Would error messages be more effective if they were pictorially represented rather than with words? Are different types of problem solving skills needed to learn different computer languages? Do children with certain learning styles learn one form of logic more easily than another? Does learning one computer language interfere with or enhance the learning of another? Do the problem solving skills learned to program a computer generalize to other problem solving situations, such as social settings?
>
> In programming the computer to teach most effectively, are there differences between school-aged populations in optimal spacing of trials? optimal number of trials in a session? optimal type, frequency and spacing of feedback? efficacy of tailored feedback for incorrect responses versus standard feedback for wrong responses (e.g., standard computer error messages)? or efficacy of forcing a correct response?

Computer programs designed to collect background information on referrals need research into the most appropriate questions and branching points. In addition, programs offering a tentative diagnosis or recommendation for further evaluation need a strong research basis. With the diversity of theoretical viewpoints represented in the field of psychology, one could envision several different programs given the same data offering conflicting recommendations Some regulation by professional associations might be necessary to guard against entrepreneurs seeking to sell their wares through such programs by recommending a treatment that uses materials they sell.

Test administration is a controversial area of development in school

psychology computer applications. Some practitioners view this application as a threat to job security rather than an opportunity to enlarge the opportunities for service delivery. Research is needed to determine the reality of this perceived threat. Research is also needed to identify differences between computer administered tests and practitioner administered tests. Studies have shown people to be more open and honest when responding to computer questions than when responding to a human interviewer (Evans, 1979). Whether the computer would be a distracting and interfering factor or an enhancing one remains to be shown.

Theoretical Issues

School psychologists may be preserving practices that have no rational basis beyond their historical roots in an earlier period of technological and theoretical development. Our most used tests may become the "QWERTY's" of the future. Will we need IQ or achievement tests if records of the child's progress are being updated daily by a computer? What would our evaluation add? Do our traditional procedures evaluate the skills acquired through interaction with computers? Do our procedures evaluate the process of learning?

Our traditional theories of how children learn may be upended by computers. We may see conceptual generalizations emerging much earlier. As children learn systematic problem solving skills through interaction with computers, they may learn systematic thinking skills before they learn to be quantitative (a reverse Piagetian development) (Papert, 1980). Their problem solving strategies may be far more sophisticated far earlier than is common now. The impact of such a growth pattern on education, both for teaching and evaluation, is indeed far reaching.

The answers to the above research questions will vary with different children. Research is needed to prevent abuse of computer applications and to help assure that computers are used appropriately with children. If a child is not learning well with a computer it will not be the computer's fault; it's just a machine. The instructional theory and the programming knowledge that implements that theory will heavily influence the success or failure of computer applications. A learning theory for technology cannot be far off. Our present psychological and instructional theories may become like the QWERTY keyboard when applied to computer technology; without rational basis and relics of another time. Perhaps it is time for research to provide us with jet engine theories for the jet engine technology with which we are going to live.

Conclusions

History is replete with examples of technology that have radically changed the way people lived, traveled, thought, fought and communicated. In even one lifetime we have seen numerous technological developments take place in our global society that may yet determine its survival.

As technology advances faster and farther, there are often feelings of alienation and futility. People despair of staying abreast of the advancements. Some think all this fuss may be very well and good for everyone else, but what's in it for me?

Many areas of computer applications in the field of school psychology have been discussed, but this monograph is not exhaustive. It is up to each professional to decide which needs can be met more effectively by a computer. How can a computer improve the quality or quantity of your work, skills, knowledge? Which tasks do not require direct human contact or interaction? Granted, there will be tasks that do not lend themselves to computer application, for now at least, but improvements and changes in computer technology are occurring exponentially.

When the pencil was invented, undoubtedly some school psychologist somewhere lamented the fact because now the children would be learning disabled. They would not have to repeat their lessons each time the rain washed away their scratches in the dirt. Whether you write with a pencil, an erasable pen or a word processor; use carbon paper, stencils or a Xerox machine; play piano, listen to the radio or watch a live concert on TV, you have accepted change and new technology. And you are passing it on. When we were children, our parents passed on new technology by buying a box that made sound and had tiny people moving around inside a little window. A television is old hat to us now and our kids don't know life without it. They are experiencing computers as we experienced television (or for those a little younger, video casette recorders). What will their children grow up with?

It is rare that an educational development so closely parallels technological developments in other areas of society. But that is what is happening with computers. They are not going to fade away like the teaching machines and last season's popular learning theory.

So there are choices to consider. We can choose to adapt to computers or to make computers fit our needs in school psychology. We can choose to do what we do now more efficiently or to use the technology innovatively and improve what we do now. We can choose to join the ranks of the "QWERTY" faithful and continue to ride the oxcart, or we can choose to soar.

References

Baker, R. (1983). "Computer Assisted Psychoeducational Report Writer". Paper presented at the annual convention of the Oregon School Psychologists Association. Ashland, Oregon.

Evans, C. (1979). The Micro Millennium. New York: Washington Square Press.

Grimes, J. & Ross-Reynolds, G. (1981). "Psychological Data Management Stystem." Paper presented at the eleventh annual convention of the National Association of School Psychologists, Houston, Texas.

Kruzas, A.T. & J. Schmittroth, Jr., editors (1981). Encylopedia of Information Systems and Services, 4th edition. Gale Research Co., Book Tower, Detroit.

McCullough, C.S. (1982). Computer Applications in School Psychology: Survey Report. A report prepared for the Assistance to the States Committee, National Association of School Psychologists.

Metzger, M. (1983). Computers and Learning Disabled Students. (1983). International Council for Computers in Education. University of Oregon. Eugene, Oregon.

Ray, S. (1982). "Computerized Protocol for the WISC-R." Paper presented at the twelfth annual convention of the National Association of School Psychologists. Toronto, Ontario, Canada.

Torrance, E.P. (1981). "Implications of Whole-Brained Theories of Learning and Thinking for Computer-Based Instruction." Journal of Computer Based Instruction. 8, 1-8.

Software References

The Learning System. Kamins, S. (1981). Micro Lab Learning Center. 2310 Skokie Valley Rd. Highland Park, Illinois 60035.

Telofacts. dilitium Press (1983). P.O. Box 397, Mt. Gravatt, Q. 4122, Australia.

Microcomputer Technical Overview

Adapted by Sue McCullough, from Dave Moursund's "Technical overview" from Introduction to Computers in Education for Elementary and Middle School Teachers.

Introduction

One can learn to use a car, electric light, record player, tape deck, radio, television or telephone without understanding the underlying technology; this is also true with computers. Even preschool children can learn to turn on a computer, load a program into primary storage and run the program. They have no trouble learning to interact with a program written for children their age, designed to hold their interest.

Why, then, a technical overview? Certainly you can learn to use a computer without understanding how it works. Still, there are good reasons to know more.

1. Computer technology is changing very rapidly. A good analogy is the automobile. In the early 1900s, a car owner needed to be able to service the vehicle and to administer to its particular needs.

Likewise, the computer field is still quite young and the the development of powerful computers--the ones apt to be used in an elementary or secondary school--is in its infancy. The educator who ventures to use a computer is still somewhat of a pioneer. Without some technical background s/he can easily flounder.

2. A computer is quantitatively different from machines that can be easily mastered. The computer has great versatility; it is a general purpose aid to problem solving. To appreciate or understand this versatility and to make effective use of the computer in problem solving take much more than superficial knowledge.

Using a computer without understanding the underlying technology is like reading without knowing how to write--it is only half the picture. One is completely dependent upon others to provide material to read. Moreover, it is difficult to appreciate how hard it is to write well without the experience of writing.

3. The magic must be dispelled. Young children often believe that there are small people inside a television set, or they may have trouble understanding how one can send "flowers by wire" through such a thin wire! What computers can do seems like magic even to adults, and some knowledge of the underlying technology is needed to understand the capabilities, applications and limitations of computers.

4. Computers have the potential to cause a major change in both the content and process of education. For this reason alone, all educators should have a more than casual insight into these machines.

5. Computers are an increasingly important part of our technological society. As an educator you are expected to be educated. It is expected that you understand and can cope with varying aspects of life in our society. Thus you should know about technology, and in particular you should know about computers.

The above arguments notwithstanding, we do not know what educators should learn about computers at this stage. A number of computer education experts have expressed their opinions via learned papers, books and speeches. These opinions vary considerably, from a need for no knowledge of underlying technology to a need for a sophisticated background in electrical engineering and computer science.

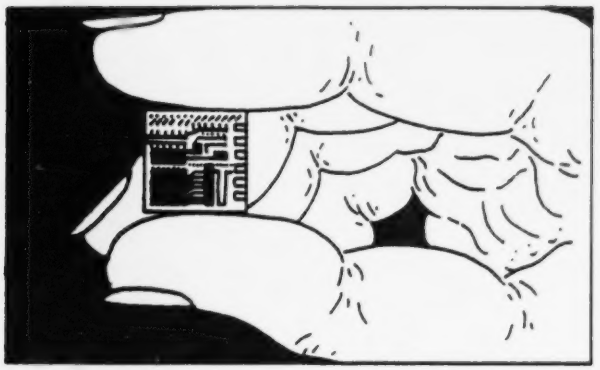
This overview will take a middle-of-the-road approach. No knowledge of electronic technology or binary arithmetic is either assumed or taught. The ideas presented here could all be included in a precollege curriculum. It is assumed that you do know how to do the following:

1. Turn on a microcomputer or gain access to a time-shared computer system.
2. Select a program from a program library and load it into primary storage (computer memory).
3. Run the program and interact with it.
4. Turn the microcomputer or timeshared terminal off.

It is also assumed that you have run at least a half dozen different programs. Thus you have some insight into both the physical machinery and the computer programs that constitute a computer system. This "how to use it" knowledge can come naturally from observing and working with others in a computer-rich environment, similar to learning how to use a television set or stereo.

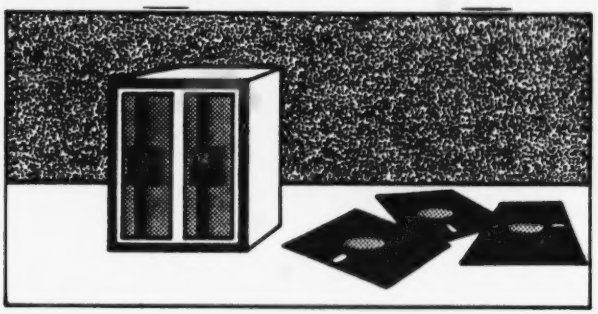
Microcomputers

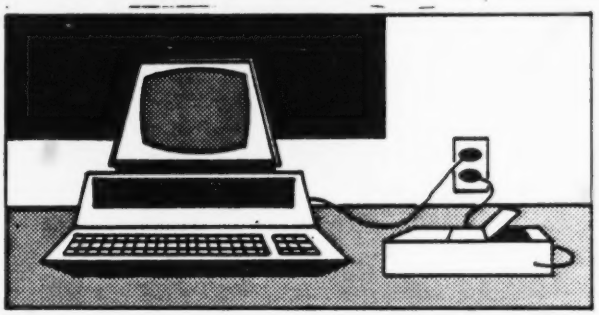
The most widely available computer system in homes and precollege education is called a microcomputer. This is not because of its small size, although a microcomputer may be as small as a portable electric typewriter or hand-held calculator. Rather, the name comes from the microprocessor, the superspeed automated computational unit that is the heart of the machine. A microprocessor is less than a cubic centimeter in size and may cost less than $10. This little device contains the equivalent of many thousands of transistors, resistors, capacitors and other electronic components. It is called a large scale integrated circuit, or a "chip." The latter name comes from the small piece (chip) of silicon used in the manufacturing process.



The typical microcomputer uses a typewriter-style keyboard for input, a television-type screen for display of input and output, and some type of magnetic medium for permanent storage of programs and data. The cheapest magnetic medium for storage of programs and data is tape. Good quality cassette tapes which will hold several programs or a substantial amount of data are very inexpensive.

An alternative to cassette tape is the floppy disk. A floppy disk is a thin, circular, flexible piece of plastic coated with the same material used on magnetic tapes. There are two standard sizes: a 5 1/4-inch diameter disk and an 8-inch diameter disk. A floppy disk drive is needed to use the diskettes. Each floppy disk holds a substantial number of programs and/or a large amount of data. Floppy disks cost slightly more than cassette tapes but are still





relatively inexpensive. Magnetic tape and magnetic disk storage will be discussed in greater detail later.

The least expensive factory-built microcomputer systems can cost less than $100. The most expensive large scale computer system may cost $12 million or more. This price range between the least expensive and the top of the line is mind boggling. What other consumer item has such a variance in price? Obviously, there is considerable difference between a $100 and a $12 million computer system. Some of these differences emerge as we study computer hardware in more detail.

Computer Software

A computer system consists of both physical machinery, called hardware, and computer programs, called software. Both hardware and software are required if the computer system is to function. In this section we give a brief introduction to software by discussing the idea of a procedure which can be carried out by a machine.

A computer program is a detailed set of instructions which tells a computer what to do. Computer scientists have defined a somewhat more general idea, called a procedure, as follows: A procedure is a finite set of instructions (steps) that can be mechanically interpreted and carried out by a specified agent.

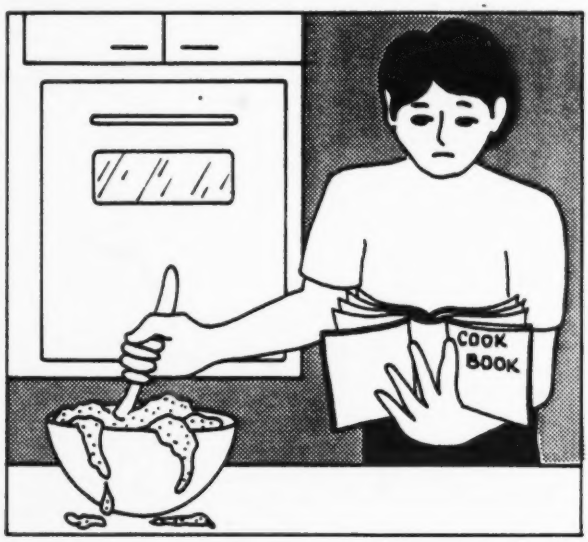
A procedure is a specification of how to solve a particular type of problem or accomplish a particular task. Notice that there are three main parts to the definition:

1. A finite set of instructions or steps; a detailed, step-by-step set of instructions that can be written into a book or stored in a computer memory.

2. The instructions can be mechanically interpreted and carried out; the instructions are simple, straightforward and unambiguous. They can be "figured out" and carried out in a machine-like, non-thinking fashion.

3. An agent is specified; computer scientists are especially interested in procedures in which the agent is a computer, or a person working with a computer.

For educational purposes it is instructive to think of the word procedure in a much broader context than just with computers. We learn procedures for tying a shoe, tuning a TV set, cooking an egg, starting a car or administering a WISC-R. Much of education, both formal and informal, consists of learning procedures to cope with specific problem situations. Often the agent in these procedures is a human being, trained to function in a machine-like fashion.



Many of the procedures we learn involve use of machines. You probably know procedures for using a washing machine and clothes dryer to clean your laundry; using a stereo to play music; or using a calculator to find the quotient of two numbers.

It is interesting to examine paper and pencil arithmetic as a procedure. The agent is a person working with paper and pencil. The person memorizes number facts (the one digit addition and multiplication tables, and so on) and the algorithms. Then the person, with little or no thinking, acts mechanically as part of the agent in carrying out a complicated calculation such as long division. Continual drill and practice is required to develop speed and accuracy; we strive to make the person increasingly machine-like in this task.

This term "machine-like" perhaps needs some additional explanation. Instruction in arithmetic for very young students includes considerable work with manipulatives (concrete objects). Later, students learn to work with the abstract symbols such as the digits and operation symbols. Eventually students reach the level where they begin to learn algorithms for working with multidigit quantities. Frequently, a considerable effort is made to motivate and explain these algorithms . So, at least initially, the student may have some insight into how the steps of the algorithm relate to the problem being solved. However, in most cases this is eventually lost. Through continual drill, the student is expected to develop speed and accuracy in tasks such as multiplication, or adding a column of multidigit numbers. The student is expected to become more and more machine-like in carrying out these tasks.

An alternative, of course, is to provide the person with a machine that can do more of the task. A pocket calculator is such a machine. A procedure to find a sum of two numbers is as follows:

1. Turn on calculator.
2. Key in first number.
3. Push the + key.
4. Key in second number.
5. Push the = key.

The machine then automatically carries out the detailed steps of an addition algorithm and displays the answer.

A procedure to be followed by a computer is called a computer program. The terms computer software, software, computer program, program, computer procedure and procedure tend to be used interchangeably by computer scientists. There are some problems whose solutions may require following procedures taking millions, or even billions, of steps. A medium-scale computer system may be able to execute these steps at the rate of a million per second.

It is important to understand that people create computer software. Without this software a computer does nothing--solves no problem. But the person who uses a computer need not be the person who created the software, any more than it need be the person who built the the hardware. The next time you use a computer, think about the computer program you're using. Keep in mind that it is merely a step-by-step set of instructions, written by a human, that is being mechanically interpreted and executed by the nature and extent of its software as well as its hardware.

Exercises

1. Suppose you have a set of cards, each containing the name of a student. You know a procedure for alphabetizing this set of cards. Write it down in a form that can be understood and followed by a sixth grader. (This is a difficult exercise; most people have had little practice in writing down the details of a complex procedure.)

2. Repeat Exercise 1, assuming that each student has a different student number, the goal being to arrange them in increasing order. Discuss in what ways your two procedures are alike, and how they differ.

3. A recipe is a procedure for preparing food, while a knitting pattern is a procedure for turning yarn into a garment. Name other types of procedures. For each, specify the usual agent and the problem being solved.

4. The federal government provides a detailed set of instructions--a procedure--for preparing a federal income tax return. Learning to be the agent who reads, interprets and executes this procedure is a difficult task. An alternative solution to preparing your own tax return is to hire someone to do it for you.

a. Discuss the educational ramifications of these two methods of solving the income tax return problem.
b. Give another example with similar characteristics.

This exercise illustrates a key idea. There is a difference between understanding the problem to be solved and being the agent that solves it. There are many problems that can be solved by a computer. Thus, the educational issue is deciding what one should learn to do unaided by machine and what should be aided by an appropriate machine. This issue has existed since the beginning of formal education, and each new machine adds new dialogue and controversy to it. The computer is such a powerful and versatile machine that it greatly exacerbates the issue.

5. Currently it takes from 30 to 60 minutes to score a complete Woodcock-Johnson Psychoeducational Battery. The potential for error is great since many tables must be entered and arithmetic calculations performed. A computer scoring program can score the WJPB in seven minutes error free. Discuss the merits of using the computer scoring program including the potential positive and negative outcomes of the time saved, and the effects on school psychology students learning to score the WJPB.

Computer Hardware

Computer hardware is the physical machinery of a computer system. It is designed for the input, storage, manipulation and output of a set of symbols. The set of symbols a particular computer uses is called its character set. The character set for an inexpensive microcomputer may rconsist of the upper case letters, digits and punctuation marks found on an ordinary typewriter.

A computer's character set may also include lower case letters and/or special graphics characters. The latter may be designed to aid in the construction and output of engineering drawings, pictures, or line, bar or pie graphs.

There are two very important aspects to a computer's manipulative abilities. First, it functions automatically, following instructions from a program stored in its memory. Second, it is fast. A medium-priced computer can execute a million program steps per second.

A diagram of the main hardware components of a computer system is given below. We will discuss each of these five main components. Keep in mind that a

computer system may range in price from less than $100 to $12 million or more. The more expensive systems tend to have more and varied input and output units, greater speed and reliability, and greater primary and secondary storage capacity.

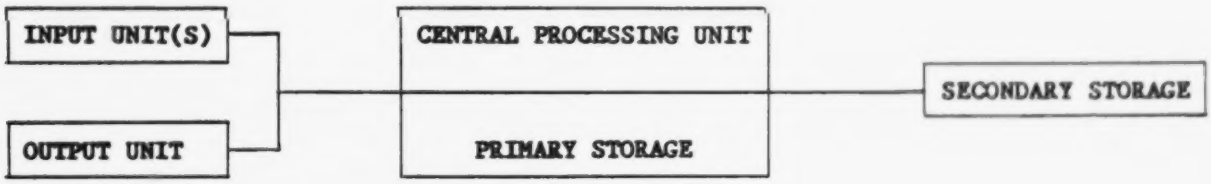


Diagram 1. Five main computer hardware components

Input Devices

Many computers use an electric typewriter keyboard for input. Anything that can be typed can be input into the computer. The hardware converts the physical motion of a key being stroked into an electrical code for the key's symbol, and stores it in computer memory.

There are many other computer input devices. You are probably familiar with punched cards, often called "IBM cards." The patterns of holes in a card are codes for characters. A card reader senses these patterns of holes, converts them into electrical impulses and stores the characters in a computer memory.

Optical scanners constitute another important category of computer input devices. The simplest of these read "mark sense" cards and "mark sense" scan sheets. You are familiar with the latter, since they are often used as answer sheets for tests to be machine scored. A more sophisticated example is provided by the bar code on grocery store items. A pattern of bars of varying width and spacing is a code for a manufacturing firm's number and an item number. A laser light is used to "read" the bar code.

Character recognition is now a well-developed technology. Computer input devices that can read a typewritten or typeset page are in widespread use. An entire page can be read in a few seconds. Some of these machines can read carefully handprinted numbers and letters. However, computer recognition of ordinary handwriting is still a research problem. This is not surprising, since many people have trouble even reading their own handwriting!

Another form of character recognition is used on all bank checks processed in the United States. Look in the lower left corner of a check and you will find an account number printed in magnetic ink containing tiny iron oxide particles. The reading head of a magnetic ink character recognition machine magnetizes these particles and uses a magnetic field detector to read the characters. When a check is being processed by a bank, the amount is printed in magnetic ink characters in the lower right corner by a data entry clerk. Once this has been done, the bank's magnetic ink character recognition machine can read both the account number and amount of the check, so that further processing can be highly automated.

The final input device we will consider is the general category of sensing devices. Sensing the movements of a knob or lever in a hand control for a TV video game provides a common example. Devices can be built to sense temperature, pressure, velocity or acceleration. These measurements are converted into digital form and input to a computer. The computer can then be used to control a process. For example, a computerized thermostat system senses the temperature at a number of places throughout an office building. The computer, taking into consideration the time of day, weather conditions and number of employees, opens and closes air vents and adjusts air conditioners and furnaces.

There are many more input devices, some especially useful in education. Examples include voice input, touch sensitive display screens, light pens, graphics tablets and television cameras. Each has educational value and educational implications. For example, consider a touch sensitive screen and/or voice input. Each can be used with non-readers. They may be quite useful in teaching young students to read or in working with handicapped students.

At one time the cost of touch panels, voice input, graphics tablets, etc., was quite high. But that time is now past. More and more we find that these are available to computer users throughout business and education, and at home. As appropriate educational software is developed to take advantage of these computer hardware facilities, we can expect their use to grow rapidly.

Exercises

1. A good typist can type 60 words per minute, figuring an average of five characters per word. A punched card can contain 80 characters, and a high speed cardreader can read 1000 cards per minute. How many words per minute is this, and how many times as fast as a good typist is it?

2. Suppose that material has been typed double spaced, so there are about 72 characters per line and 30 lines per page. An optical scanner can read this material at the rate of one page every three seconds. Compare this speed with that of the typist and the cardreader of Exercise 1.

3. A good (human) reader can read 500 words per minute. Compare this speed with the cardreader of Exercise 1 and the optical scanner of Exercise 2.

4. Many grocery stores now have electronic scales connected to their cash registers. Talk to a grocery store clerk to learn how these machines work. What is the clerk's attitude toward this computer technology? Does the existence and widespread use of

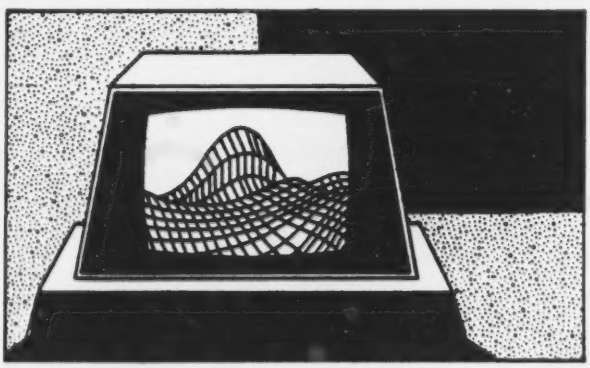
electronic digital scales have a potential impact upon the content of the elementary or middle school curriculum?

5. Mark sense scan sheets are used in most grades for standardized group and individual tests. Consider the consequences of a child marking answers in the wrong section or response square accidentally, leading to errors in scoring. How would such errors be detected?

Output Devices

An electronic typewriter can be modified to serve both as a computer input device and output device. Such a keyboard terminal prints the computer output on ordinary sheets or rolls of paper, and is called a hardcopy terminal. The term "hardcopy" is used to distinguish this permanent printed output from a non-permanent screen display, sometimes called softcopy output. Hardcopy terminals often use other forms of printing mechanisms and may require special paper, such as heat sensitive paper.

The least expensive screen display keyboard terminals use a television set, or a modified television set, as a display mechanism. The display screen of a TV set is a cathode ray tube (CRT). CRTs are also used in oscilloscopes and in other electronic display mechanisms. Higher quality screen display keyboard terminals use higher quality, higher resolution CRT displays. With a higher resolution display, one can draw intricate architectural or engineering drawings, graphs and pictures. The field of computer graphics has emerged as an important aspect of computer science.



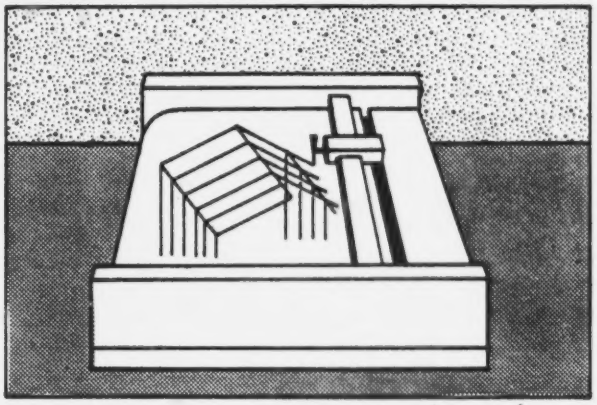
The TV set used as a computer output device may be a black and white set, but it may also be a color set. Indeed, color output is now quite common. This certainly adds a new dimension to computers in education. Some of the educational materials now available are more than adequate competition for the Saturday morning cartoons on TV!

The printing speed of a hardcopy keyboard terminal can vary widely, depending upon price and quality. The old fashioned model 33 and model 35 Teletypes, once widely used as computer terminals, print 10 characters per second. Many of the newer hardcopy keyboard terminals have printing speeds of 30 to 60 characters per second, or even higher. A typist's speed is often stated in words per minute, figuring an average of five characters per word. Thus, a printing speed of 10 characters per second is two words per second, or 120 words per minute. A printing speed of 60 characters per second is equivalent to typing 720 words per minute, or about 10 times the speed of a good typist.

But such printing speeds are slow relative to those available on line printers. A line printer prints an entire line nearly simultaneously. Printing

speeds of from 300 lines per minute up to 2000 lines per minute are possible on impact printers. In an impact printer, a hammer presses an inked ribbon against the paper, as in a typewriter. Use of a xerographic (non-impact) printing process allows speed up to 20,000 lines per minute. Line printers generally have long carriages, allowing lines longer than will fit on a notebook-sized page. A line length of 132 characters is common. Thus, a line printer may print tens of thousands, or even hundreds of thousands of words per minute.

Scientists, engineers and architects frequently make use of a computer output device called a plotter. A plotter contains one or more pen mechanisms. Under computer control, the pen is quickly positioned at desired spots on a paper, raised or lowered, and moved rapidly. (Some plotters move both the pen and the paper, while others move only the pen.) Pen movements as short as a



hundredth of an inch, with several hundred pen movements per second, are possible. A plotter may have several pens with different colors of ink. Quite intricate and colorful patterns or drawings can be output by a plotter.

There are many other types of computer output devices. For example, a computer can prepare punched cards, print on microfilm or on larger photographic plates to be used in photo typesetting, run a Braille writer, output music, or even output voice. Also, computers can be used to control devices such as furnaces, air conditioners, all kinds of factory machinery, airplanes and rockets. A large part of all the computer equipment currently being produced is actually being used in such process control applications.

Sophisticated input and output devices can be combined to make tools especially valuable in education of the handicapped. A hand-held, battery powered "talking" calculator has been commercially available for many years. As each key is depressed, the calculator speaks (provides voice output) the key's symbol. After an answer has been calculated, the calculator can be directed to speak its digits. Needless to say, the talking calculator is quite useful to blind students.

As another example of use of sophisticated computer technology, one can now purchase a reading machine, designed to be used by blind people, which has a TV camera as an "eye" for reading books and other printed material. It uses a voice synthesized to speak what it reads. This machine, developed in the latter part of the 1970s, is an excellent example of how computer technology can make a very important difference in the lives of many people.

Exercises

1. Suppose that a line printer has a 132-character line length. How many words per minute, figuring five characters per word, is a

line printer speed of 300 lines per minute, 1500 lines per minute, and 20,000 lines per minute? How many times faster than a 60-word-per-minute typist is each of these?

2. Computerized phototypesetting is now common in the newspaper industry and in many other printing shops. In the past decade there have been many prolonged newspaper strikes by unions opposed to the introduction of this equipment. Study this aspect of computers in automation and write a report on what you learn.

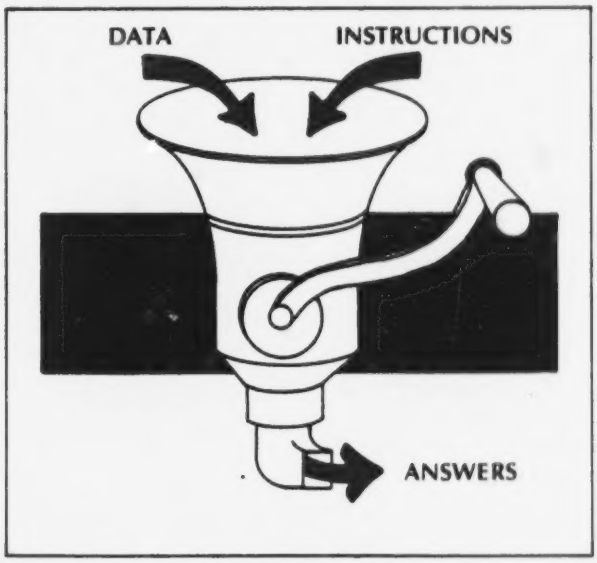
3. A number of companies now specialize in the computerized scoring of psychometric tests. Make a list of some tests that you think could be scored by computer. Discuss how cheap and ready access to such a service might affect a school psychologist.

4. Software for microcomputers is also available that not only scores tests but also provides an interpretation of individual scores. There may be comparisons of scores across two or more tests as well. Discuss the implications of this, including ethical, theoretical, statistical and research factors, evaluation criteria for the software, and quality control.

Central Processing Unit

The heart of a computer is the central processing unit (CPU). The CPU has two major components. First, it contains a control unit that can read and understand an instruction (a program step) that is in primary storage. Second, it contains an arithmetic-logic unit, which can be thought of as a superspeed calculator.

The CPU operates in a two-step cycle. In the first step it fetches an instruction from primary storage (computer memory) and interprets its meaning. In the second step it executes the instruction. The execution step may require fetching additional data from primary storage. For example, an instruction may indicate that the numbers in two specified locations are to be added. During the execute cycle the two numbers are brought into the arithmetic-logic unit and added.



The most impressive aspect of a CPU is its speed. The time to carry out a fetch cycle or an execute cycle is measured in microseconds (millionths of a second) or nanoseconds (billionths of a second). A relatively inexpensive microcomputer can carry out a fetch cycle in a microsecond, while a more expensive computer may be 10 to 100 times this fast. The execution of a simple instruction on a microcomputer may take several microseconds, while a more expensive computer may be 10 to 1000 times as fast. The very fastest modern computers can execute an instruction in 1.25 nanoseconds.

It is difficult to comprehend the meaning of the speed of a CPU. A medium scale computer can carry out a million instructions in a second. An instruction might be an arithmetic operation (+,-,x,/), a logic operation (compare two quantities to see if they are equal), or a movement of data between various memory locations. How long do you think it would take you to carry out a million arithmetic operations either mentally or using pencil and paper? A pencil and paper long division may take a person a minute or so. During this time a computer can do more arithmetic than a typical person does in a lifetime.

Other examples add to this insight. You can walk perhaps 5 km/hr. Thus, to walk across the United States would require several months. If your walking speed increased by a factor of a million, you would be able to cross the United States in less than four seconds! Or suppose that your reading speed increased by a factor of a million. You would then be able to read several thick novels in less than a second.

Exercises

1. Select a large dictionary and estimate how many words it contains. Suppose you were going to look up a word by comparing it with each word in the dictionary, starting at the beginning of the alphabet. That is, you would look at every word beginning with A, then every word beginning with B, and so on. Estimate how long it would take you to find a specific word beginning with L. Then estimate how long it would take if you could read and compare words at a million times your current rate.

2. Time yourself as you do a calculation such as 38.9 X 614.3 using pencil and paper. Estimate how long it would take you to do a million multiplications of this complexity, working eight hours per day, seven days per week.

Suppose that a computer which can do a million multiplications per second rents for $200 per hour; what would the cost be to use this machine to do a million multiplications?

Computer Memory (Primary Storage)

Every computer has memory--space where programs and data can be stored either temporarily or permanently. For most computers the memory is divided into two categories: primary storage and secondary storage.

Primary storage operates at a speed comparable to that of a CPU. This is necessary because when a program is being executed there is continual interaction between primary storage and the CPU. For example, an instruction may need to be brought into the CPU. An answer calculated by the CPU may need to be placed into primary storage.

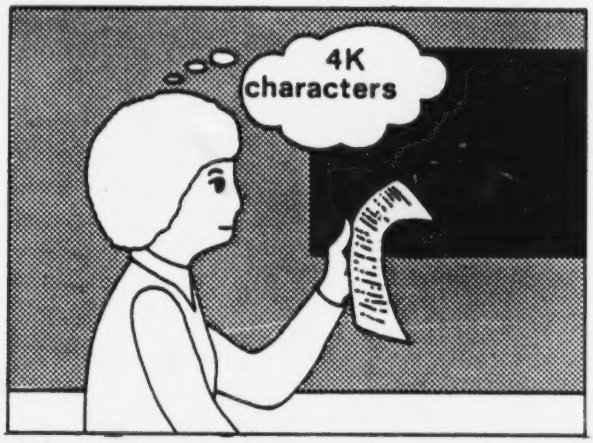
One way to state the speed of a computer is to give its memory cycle time. This is the time to move a character from primary storage into the CPU; it is

also the time to move a character from the CPU into primary storage. Typically, the CPU can execute a simple instruction, such as to increase a particular number by one, during this memory cycle time of 500 nanoseconds. Such a machine can count from 1 to 2,000 in a thousandth of a second!

In addition to giving the memory cycle time, a standard way to describe the size or capability of a computer system is to give its memory size. The unit of measure of computer memory is the byte, which is the same as one character of storage. A digit, letter or punctuation mark can be stored in one byte of memory. Computer scientists frequently use the letter K to stand for the number two to the tenth power, which is 1024. They state the size of a computer memory as a number of K's of storage.

For example, the most inexpensive microcomputer is apt to have an 8K or 6K primary storage. Many microcomputers have 48K, 64K or even 128K of primary storage. A medium scale computer may have a 256K or 512K primary storage, while a large scale computer will have primary storage of 1024K (called a megabyte) or several megabytes. The larger the primary storage, the larger the program and the amount of data that can be immediately available to the CPU.

One can get a feeling for the size of primary storage by comparing the numbers with the amount of print on a typed or printed page. A full page of single spaced typing is about 4K characters. Thus the primary storage of an 8K machine is roughly equivalent to two pages of single spaced typing. The primary storage of a four megabyte machine is roughly equivalent to a thousand single spaced pages of typing.



Primary storage is temporary storage; what is stored there as a person runs a program is replaced by the program and data of the next person to use the machine. Also, the contents of primary storage are usually erased when the machine is turned off. For these reasons, almost all computer systems have some type of more permanent, large capacity secondary storage. This is discussed in the next section.

Exercises

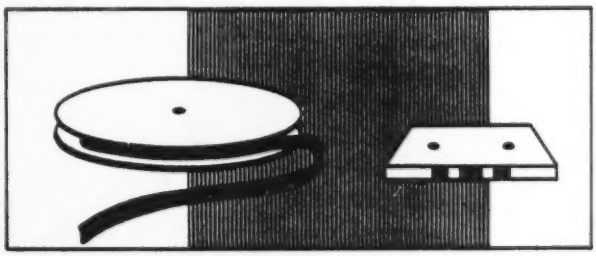
1. Select a novel or college textbook, and then determine whether the contents of the book would fit into the primary storage of a one megabyte computer (1024K). Estimate the length of the book by counting the number of characters on one page, including the blank spaces between words. Each character occupies one byte of storage. Count three different pages: the second, the tenth and twenty-fifth. Explain any differences in your answers.

2. What is the binary number system? Why do you think that computer scientists use two to the tenth as a measure of memory size, and that typical memory sizes are 8K, 16K, 32K, 64K, etc.?

3. If you were choosing a microcomputer primarily for word processing (writing and editing text), how much primary storage would be a minimum requirement for your needs? Determine the primary memory storage necessary for a two-page psychological report, six-page and 10-page report.

Computer Memory (Secondary Storage)

Secondary storage, often called bulk storage, is for more permanent storage of large quantities of data and programs. The most common and widely used forms of secondary storage make use of magnetic tape, magnetic disks or other related magnetic media. The magnetic tape used on computer systems is similar to that used on hi-fi systems, but may be of higher quality.



Inexpensive microcomputer systems may use a tape cassette recorder for secondary storage. These recorders, costing less that $100, are widely available in radio/television stores. A 15-minute tape can store about 32K to 64K bytes, depending on the computer being used. However, these cassette systems are not particularly reliable, and loss of programs or data is frequent.

More expensive tape systems, costing hundreds or even many thousands of dollars, are often used on more expensive computer systems. An industry-wide standard type of tape is a half an inch wide and comes in reels of 600, 1200 and 2400 feet in length. Recording densities of 800, 1600, and 6250 bytes per inch are common. A 2400 foot reel of tape, recorded at 6250 bytes per inch, stores 180 million characters.

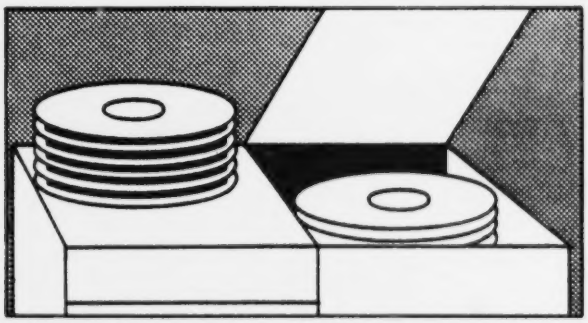
The storage of millions of characters is somewhat difficult to comprehend. The typical mystery book or short novel is about a half million characters in length. A 500-page book (a full-length novel) is about a million characters.

The 2400-foot reel of tape is about 30 cm in diameter. Recorded at 6250 bytes per inch, it can store the equivalent of about 180 full-length (500-page) novels. Such a reel of tape costs about $15. It is a highly reliable, long-life storage medium. With proper care and infrequent use the tape will last for several years.

Storage on magnetic tape has one serious drawback. A tape must be read sequentially. If the program or data one wants is near the end of a 2400 foot reel it can take many minutes for the reading mechanism to reach it. Suppose, for example, a bank kept its customer account records on a tape. When a customer requests information about his/her account, several minutes of tape drive time may be used to provide the answer.

An alternative to this procedure, used on almost all large computer systems, is magnetic disk storage. Flat circular aluminum plates are coated with iron oxide, the same material used on magnetic tape. The plate, called a disk

or a hard disk, is spun rapidly. A read/write arm is quickly positioned over any spot on the disk. Thus, access to any program or data on the disk occurs in well under a second.



A disk pack consists of a number of disks mounted on one spindle with air space between them for read/write arms. In a disk pack the top and bottom of each plate is used as storage medium, except for the top of the top-most plate and the bottom of the bottom-most plate. An 11-plate pack, with 20 recording surfaces, may store 300 million to 600 million bytes or more. A single recording surface of a hard disk may store anywhere from 15 to over 30 million bytes.

Again, let's try to understand what these numbers mean. The disk pack is about 35 cm in diameter and 15 cm high. It costs about $300. It stores the equivalent of about 300 to 600 full length novels. Access to any particular program or set of data on a disk pack is perhaps 1/10th of a second or less.

There are many other secondary storage devices. The idea is to store large amounts of information cheaply and reliably. Gradual progress is occurring on a year-by-year basis, with an occasional new idea every few years. Of particular interest to users of inexpensive computer systems has been progress in developing floppy disks; thin, flexible plastic disks coated with iron oxide material. An eight-inch-diameter disk, costing less than $5, can store a half million bytes. A floppy disk drive, which reads and writes eight-inch floppy disks, costs about a thousand dollars.

A mini-floppy disk is now quite common. It is 5 1/4 inches in diameter and costs under $4 per disk. A mini-floppy disk drive costs less than $500, and one disk stores about 100,000 to 200,000 bytes. Still smaller floppy and/or rigid disks became commercially available in 1982. Storage capacities continue to increase. Also small hard disk storage systems are rapidly gaining acceptance. It is now feasible to equip a microcomputer with both a floppy disk drive and five or 10 megabytes of hard disk storage. The latter adds between $1000 and $2000 to the price of the computer system.

Floppy disks are cheap and relatively reliable. They are much more reliable than cassette tapes, and much more convenient to use. However, they are less reliable and have less storage capacity than the larger hard disks discussed earlier.

Another secondary storage device that will eventually be common in microcomputers is called bubble memory. Bubble memory is manufactured using many of the same ideas used to produce the large scale integrated circuitry for a CPU or primary memory. However, it is permanent memory, like magnetic tape or disk. Of course it can be erased, so that it can be used over and over again. Bubble memory is highly reliable, since it has no moving parts. Right now it is more expensive than floppy disk secondary storage, but rapid decreases in cost are occurring. It seems likely that many microcomputers of the future will contain both bubble memory and floppy disk memory for secondary storage.

Exercises

1. A 2400-foot reel of tape is recorded at a density of 800 bytes per inch. How many characters can it store? Solve the same problem for recording densities of 1600 bytes per inch and a 6250-foot reel of tape.

2. A very high-speed tape drive has a speed of 125 inches per second. How long will it take this type drive to read a 400-foot reel of tape?

3. An eight-inch floppy disk costs $4 and stores a half million bytes. A large disk pack costs $300 and stores 300 million bytes. What is the cost per byte of storage for each of these disks?

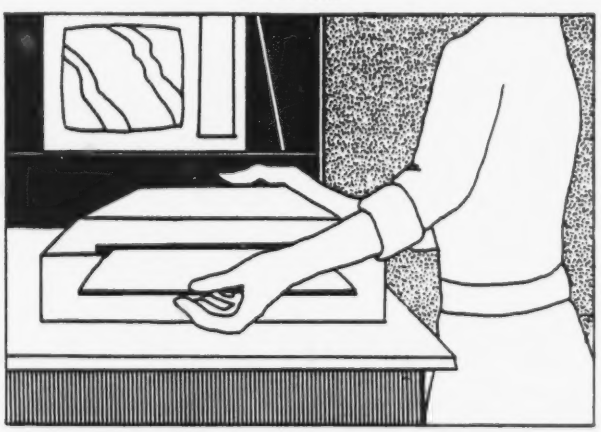
4. A medium-sized school district has 10,000 students. For each student, the district maintains an extensive set of data such as student and parents' names and addresses, academic record and attendance record. Discuss the feasibility of using a microcomputer with an eight-inch floppy disk drive to store and process this data.

5. A certain small college's library contains about 100,000 books. The college president suggests storing the contents of all these books on large disk packs, providing access via computer. Discuss the feasibility of this project. Take into consideration that a disk drive for a large disk pack costs $15,000 or more.

6. A 2400-foot reel of tape, recorded at a density of 6250 bytes per inch, is being printed on a line printer that prints 132-character lines at the rate of 1000 lines per minute. How long will it take to print the entire tape?

Videodisc

The videodisc is primarily a product of the television industry. The goal was to develop a method better than videotape for the storage and retrieval of television programs.



The results have been spectacular! One type of videodisc system uses a laser light beam to read a rapidly spinning plastic disk. One side of a disk contains 54,000 individual pictures (frames), the equivalent of a half hour of

television. These disks can be produced cheaply and rapidly, using a stamping process similar to that used on phonograph records.

This videodisc player can be hooked to a microcomputer. Under computer control any single frame can be accessed and displayed. Forward, backward, fast and slow motion are all possible. The videodisc system is equipped with two sound tracks, which can be useful in bilingual education or in reaching different types of audiences.

The computer-controlled videodisc system adds yet another dimension to instructional media. A number of education research projects are developing demonstration instructional materials and exploring the effects of using these materials in education. Materials are being developed for special education, general education, military education and for industrial and business education. Over the next five to 10 years, the videodisc will come into millions of homes. Computerized videodisc systems will begin to make a significant contribution to education.

GLOSSARY

Algorithm

A finite, step-by-step set of directions guaranteed to solve a specified type of problem. Algorithms are an important part of mathematics. Students learn algorithms for the addition, subtraction, multiplication and division of whole numbers, decimal fractions and fractions. The term algorithm can also be used to describe a procedure for looking up a word in a dictionary or for alphabetizing a list of words. See also: Procedure.

Artificial Intelligence (AI)

The branch of computer science that studies how smart a machine is or can be. Computers can play chess, checkers or backgammon at the level of a state champion. They can assist in medical diagnosis, aid in foreign language translation, and even carry on a limited conversation. Research in AI has led to computers that can accept spoken commands and can "see" using a television camera for an eye. The range of problems that AI can help solve is continually increasing and overlaps greatly with the types of problems students study in school. This raises the issue of what people should learn to do mentally, what they should learn to do using pencil and paper or other simple aids, and what they should learn to do making use of a computer. This is one of the most challenging curriculum problems our schools have ever faced.

BASIC

A computer programming language developed by Kemeny and Kurtz at Dartmouth College in the early 1960s and now available for use on almost all computers. The language was specifically designed to fit the needs of college students, but is also widely used in business, in precollege education and by people who have home computers. (See Logo and Pascal for brief discussions of other programming languages suited to the needs of precollege students.)

Binary Digit

One of the symbols 0 or 1; often called a bit. The binary number system uses just two symbols to represent numbers. Starting at zero, binary counting goes 0, 1, 10, 11, 100, 101, 110, 111, 1000, 1001, and so on. These correspond to the decimal notation numbers 0, 1, 2, 3, 4, and so on.

Electronic circuitry can easily be designed to represent binary symbols (for example, current is flowing or not flowing) so that computer designers have chosen to use the binary number system inside of computers. Algorithms exist for translating between binary and base 10 notation, and these are incorporated into most computer systems.

Thus, computer users enter their data using base 10 notation, while the computer actually carries out computations using binary circuitry.

Bit

Binary digit.

Bug

An error in a computer program. The process of searching for bugs and correcting them is an important part of computer science and is called debugging.

Byte

One character of computer memory storage. In describing a computer, one frequently gives the number of bytes of internal storage and then discusses the external storage. For example, a microcomputer may have a 48K (K=1024) internal memory and have two floppy disk drives, each using disks with a capacity of about 150,000 bytes.

Cathode Ray Tube (CRT)

The picture tube of a television set, and the type of display screen used on most computers. Depending on the computer system, a CRT may be limited to displaying just alphabetic and numeric characters in black and white, or it may be able to display full color graphics.

Central Processing Unit (CPU)

The part of computer hardware that fetches instructions from internal memory, interprets their meaning and carries out the instructions. The CPU of a modern, medium-scale computer may be able to process 10 million instructions per second.

Character

A letter, digit, punctuation mark or other symbol from a specified symbol set. A computer is designed to work with characters and with strings of characters. For example, a word is a string of one or more alphabetic characters and a number is a string of one or more numeric characters.

Chip

A fingernail-sized circuit containing a large number of transistors and connecting components, often called an integrated circuit. It is called a chip because the manufacturing process makes use of a piece (chip) of silicon. The transistor was invented in 1947 and became commonplace in computers in the early 1960s. Soon people learned to manufacture a single circuit containing the equivalent of dozens or hundreds of transistors and other electronic components. The number of components in an integrated circuit has grown over the years, so that now people speak of large scale integrated circuits (LSI) and very large scale integrated circuits (VLSI). Currently it

is possible to manufacture a single chip containing the equivalent of about a half million transistors and other electronic components. Such a VLSI may serve as the CPU of a powerful microcomputer.

Computer Graphics

The use of a computer to create pictures, drawings, graphs. Computers are quite useful in commercial art and are now standardly used to help draw the cartoon shows on television. Recent science fiction movies have made extensive use of computer-generated sequences. Computer graphics are of growing importance in business and industry since they provide a powerful tool for the manipulation and display of complicated data.

COBOL

COmmon Business Oriented Language, a programming language especially designed for use in business. Now more than 20 years old, this language is still the most widely used programming language for business problems. Since the language was designed strictly for use in business data processing departments, it is not a good first programming language for most students.

Computer-Assisted Learning (CAL)

Any use of computers to aid in the teaching and/or learning process. Early research in CAL began in the 1950s, and now many thousands of studies have been completed. These studies have helped lead to improvements in the quality and overall usefulness of CAL. It seems likely that CAL will grow in importance and will eventually be the dominant mode of instruction in our schools.

Computer Literacy

This widely used term is not precisely defined, but refers to a level of computer knowledge and skills. Many educators suggest that all students or teachers should become computer literate. This generally means they should gain a functional, working level of knowledge, suited to their everyday needs.

Disk

A flat, circular plate coated with magnetic iron oxide and used as an external storage device in computers. A single floppy disk may store 150,000 characters while a hard disk pack may store a half billion characters or more. A disk drive gives rapid access to programs and data stored on a disk.

Hardware

The physical machinery part of a computer system. It includes input, storage, manipulation and output units. The hardware for a complete computer system may range in price from a few hundred dollars to many millions of dollars.

Information Retrieval (IR)

The computerized storage and retrieval of information. The external storage devices used on computers are large enough to store a dictionary, encyclopedia or many books. Eventually these devices will store huge libraries. IR is now commonplace in business, government and research. Eventually it will be common in schools and homes.

Internal Memory

The fast-memory part of a computer's storage system. It contains the program that is being run and the data as it is being processed. An inexpensive microcomputer may have an internal memory that stores a few thousand characters while the most expensive computers have internal memories that store millions of characters.

K

Computer scientists use this symbol as a measure of storage capacity, with K = 1024. This is the number 2 raised to the 10th power.

Logo

A programming language developed by Seymour Papert especially for use by young children. The language makes it particularly easy for solving certain computer graphics problems, learning some aspects of geometry and for learning some important ideas about programming.

Microcomputer

Any computer whose CPU consists of one or a small number of large scale or very large scale integrated circuits. Generally a microcomputer system is priced under $10,000, although there are no precise bounds on this.

Microsecond

A millionth of a second. A medium-speed computer, costing perhaps a half million dollars, can perform 10 multiplications in a microsecond. Such a computer can do more arithmetic in a minute than a person is apt to do by hand in a lifetime.

Modeling and Simulation

A model is a representation of certain key features of an object or system being studied. Scientific models often make use of complex mathematical formulas; use of the models may require substantial amounts of computation. Computers are now a common aid to modeling. This part of computer and information science is called modeling and simulation.

Nanosecond

A billionth of a second. The very fastest computers now under construction are approaching a speed of one operation per nanosecond. Soon we will have a computer that can count from 1 to 1,000,000,000 in a single second!

Optical Character ition

The machine r of mark-sense can sheets, bar codes and typewrit printed materials. This is now a common method of ing data to a computer system.

Pascal

A programmin age especially developed for use in computer and infor science courses. It is now commonly used in t st college course for students planning to major puter and information science. Pascal is a substa y more complex programming language than BASIC or Logo

Procedure

A detailed, y-step plan for solving a specified type of problem. is no guarantee that the plan will work (it may conta ug). Computer scientists are interested in proc that can be carried out by a computer; such pros are called computer programs. (See also Algorithm.)

Software

A detailed, s-step set of directions designed to be carried out by rdware of a computer system. A computer system co of hardware and software. In many applications the se may cost as much or more than the hardware. Howevers piece of software is widely used, its development co be shared among many users, so the retail price may be modest. Some very sophisticated computer games andstructional programs sell in the $20-$50 price rang

Timeshared Computi

A form of int ve computing in which a number of terminals share th ry and central processing facilities of a computer syst his decreases the cost per user and can allow convenie munication among the users.

Word Processing

Use of a comp ystem as an automated typewriter. Material being typ be viewed on a display screen, so that corrections ar before one outputs to paper. Stored material suc standard addresses, paragraphs or form letters can be to increase the productivity of a word processor oper

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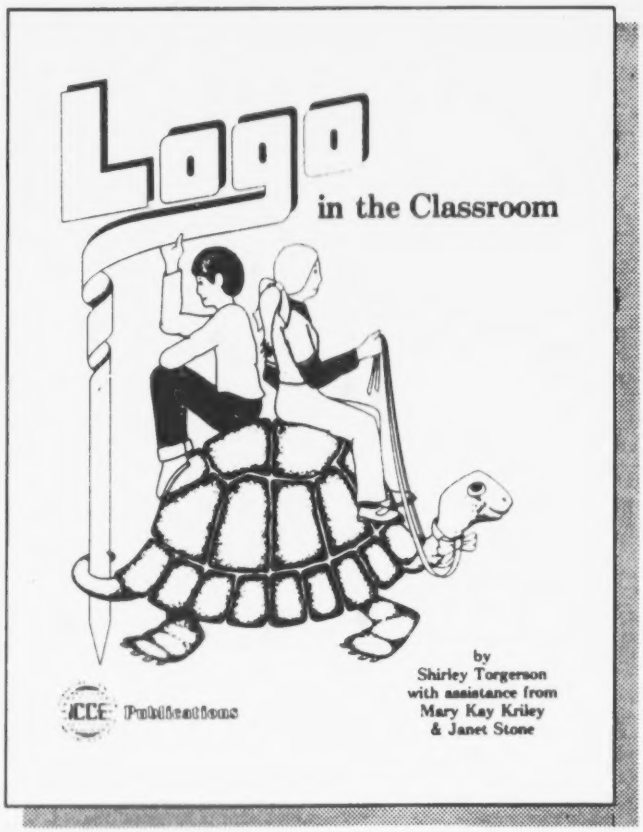

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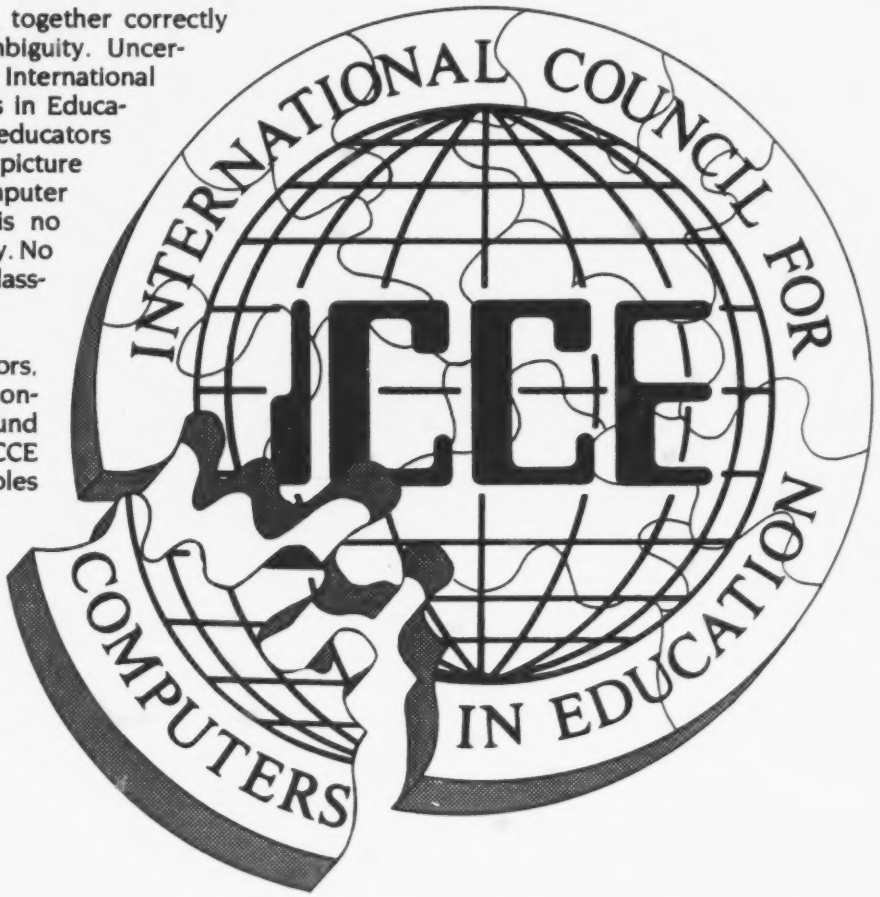

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